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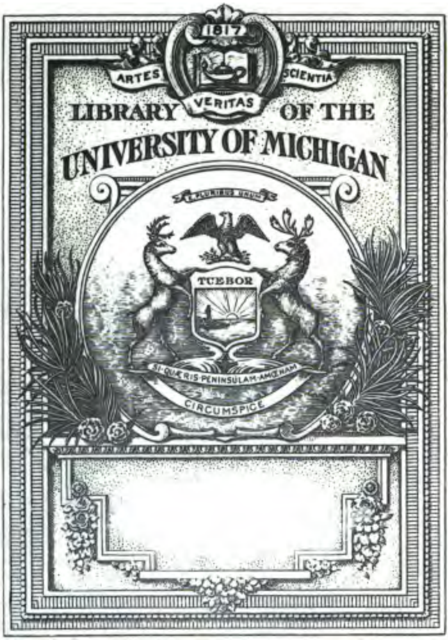

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THE PRACTICAL GASOLINE ENGINE

A MANUAL OF GAS AND
GASOLINE KNOWLEDGE

BY

E. W. LONGANECKER, M.E.

REVISED BY
BERTON ELLIOT

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PREFACE

The universal use of gas and gasoline engines is one of the remarkable features of the age. Automobiles, aeroplanes and motor boats are driven by them, in fact owe their very existence to them. Farm life has been largely revolutionized by them. Workshops of all kinds are run by them—pumps driven—irrigation carried on—wells dug—railway handcars propelled—vacuum sweepers operated—country electric light and water supply made possible—all by gasoline power. In fact there is hardly a purpose for which power is required, where efficiency, speed, economy, reliability and durability are chief considerations, that is not being successfully met with the gasoline engine.

This book is intended as a manual of gas and gasoline engine knowledge for those who want practical information in very condensed and convenient form. Technical language has been avoided wherever possible, so that those without previous experience with gas engines should have little difficulty in following the text. Convenient arrangement has been aimed at; the system of indexing paragraphs being one that will be found extremely convenient for quick reference.

The book has been revised since publication and kept up-to-date so that it contains the latest and best in modern gas engine construction and practise.

Special care has been given to such questions as may arise in the minds of prospective purchasers as well as to those who desire to become fully informed on the management, care and operation of gas and gasoline engines. It is indispensable as a hand book to practical engine men.

The general principles set forth in this book may be applied to any of the engines now in use, known variously as gas, gasoline, oil, kerosene, explosive, internal combustion, stationary engines, etc., which are either different names for the same engine or of slight difference in detail of design or general management, the basic principles being the same.

If the reader will become thoroughly familiar with the contents of this book, he will find himself equal to most emergencies where the engine refuses to run smoothly or where the trouble is difficult to locate.

To the prospective purchaser, owner or operator, in fact to all who are in any way interested in gas or gasoline engines, this book is respectfully dedicated.

CHAPTER I

INTRODUCTORY

1. **A Gas Engine** may be defined as a Motor or Prime Mover which derives its power from the Combustion, within its cylinder, of a mixture of gas and air in the proper proportion to form an explosive.

2. The **Combustion** or burning of this charge of gas and air is occasioned under a close or heavy compression, a result of the inward movement of the piston after the charge is admitted. The result of igniting this mixture under the heavy compression is what is commonly called an "explosion."

3. This explosion causes suddenly a high degree of heat within the cylinder behind the piston, which heat results in a great **Expansive Force,** creating an enormous pressure against the piston. This drives the piston rapidly and forcibly on its downward movement. The piston is connected to a crank shaft by means of a connecting rod, which, aided by the fly wheel, transforms the power from the back and

forth motion of the piston to the revolving motion of the crank shaft, and brings the piston back to its initial position.

4. **Fuel**—A number of combustible products are adapted for use as fuel in explosive engines. The most commonly employed are Gasoline, Naphtha, Benzine, Kerosene, Distillate, Crude Oil, also Natural and Producer Gas.

5. **Gasoline,** or other fluid fuels are vaporized or carbureted by mixing with air, generally by means of a device known as a carbureter, to form the explosive mixture.

6. **Birth of the Gas Engine**—As early as 1680 Huyghens suggested the use of gunpowder in an explosive engine. This suggestion engaged the attention of other minds.

M. Beau de Rochas advocated a Four-Cycle idea in 1862. But the real practical demonstration which proved that the gas engine could be made a success was made by Lenoir in 1860, and Hugon, Siemens, Boulton, Crosley and Dr. Otto a few years later designed engines that proved the gas engine a success beyond a doubt.

7. **Four Cycle and Two Cycle**—All gas engines are divided into two general types—four cycle and two cycle. In both types there are four cardinal operations that must be accomplished in sequence to produce a power impulse.

1st, charge must be drawn into cylinder—

2nd, it must be compressed—

3rd, it must be ignited—

4th, the exploded mixture must be ejected.

8. **Four Cycle**—The four cycle type requires four strokes of the piston or two revolutions of the crank shaft to perform the complete cycle of operations necessary to give a power impulse.

1st,—On the downward or suction stroke of piston a charge of explosive mixture is drawn into the cylinder. In other words inhaled.

2nd.—On the return movement of piston the charge is compressed. This is termed the compression stroke.

3rd.—As the piston reaches top of second stroke the explosive mixture is ignited, forcing the piston downward on its third or power stroke.

4th.—On the next upward stroke which is called the exhaust stroke the burnt gases are ejected from the cylinder.

These operations are repeated in order.

9. In a four cycle engine the charge enters and leaves the cylinder through valves.

10. **Two Cycle**—Two cycle engines require two strokes of the piston or one revolution of the crank shaft to give a complete power impulse.

11. In two cycle engines the crank case is made air tight, which is necessary because a charge of explosive mixture must be received by the engine somewhere at the same time the previous charge is being compressed ready for the explosion.

12. The mixture instead of entering and being expelled through valves which open and shut passes in and out through ports or openings which are covered and uncovered by the piston in its travel.

13. Two cycle engines are divided into two and three port systems.

14. Following the operation of a three port engine.

On the upward travel of piston a charge of explosive mixture is drawn into the crank case by suction caused by the upward stroke of piston, and at the same time a previous charge is compressed in the cylinder above the piston.

As piston reaches the extreme top of upward travel, the charge of explosive mixture is ignited, forcing piston downward, on which stroke the burnt mixture is ejected and a fresh charge forced from the crank case through a by-pass into the top part of cylinder.

Above operations are then repeated.

15. In the two port system the principal difference is in the manner in which

the charge of explosive mixture is drawn into the crank case. In the two port type, the charge enters crank case on the upward stroke of piston through a check valve, which opens when piston starts upward and closes automatically on the downward travel.

16. In both two and four cycle engines, while the details of performing the various operations are accomplished in different ways by different designers, the location of ports and valves are different, etc., the above fundamental principles hold in all gas engines. The operations also are identical in single and multiple cylinder machines.

17. Theoretically the two cycle engine should develop twice as much power as a four cycle, as a power impulse is made with two strokes of the piston whereas four strokes are required with a four cycle. However there are certain losses of power in two cycle engines caused by leakage, double compression of mixture, imperfect scavenging of cylinder, etc., which practically offset the fact that a power impulse is produced twice as often in the two cycle type.

18. Two and four cycle engines each have their own particular advantages for different kinds of work, and it depends considerably on the requirements as to which will give the best results. In the past, four cycle engines have

been used most extensively, but the perfection of the two cycle engines within the last few years has greatly increased the use of this type.

CHAPTER II

CONSTRUCTION

19. The principal parts necessary to the construction of a Gas Engine are Cylinder, Base or Crank Case, Piston and Piston Rings, Connecting Rod, Crank Shaft and Flywheel.

20. In addition to these parts a certain amount of equipment is required to operate the engine which, however, varies more or less with each outfit—such as carburetor, ignition equipment, governor, etc. These will be taken up later on.

21. **Cylinder.** Cylinders are generally made of gray iron castings.

22. In some engines, cylinder head is made detachable, and in others cylinder head is continuous with the walls of the cylinder, being part of the same casting.

23. Cylinder is usually cast with water jacket although the water jacket is sometimes cast separate and fitted around the cylinder.

24. In four cycle engines, inlet and exhaust valve openings are cast into the head or onto the sides of one end of

the cylinder. With reference to the location of valve openings, this has very little to do with the success or failure of the engine, so long as they open into the compression chamber. Locations are usually selected where believed to be most convenient to operate the movement of the valve.

25. The metal in the walls of the cylinder should be of uniform thickness in its entire circumference and from one end to the other, so as to allow equal heat expansion and contraction throughout.

26. The bore of the cylinder should be as nearly perfect as machinery, handled by careful and skilled mechanics, can make it. The igniting end of the cylinder should be smooth and free from projections and sharp corners. Cylinder walls are generally from 3/8″ to 1″ thick, depending on the size of the engine. The metal in the walls should be free from sand holes. In four cycle engines the valve ports should be of ample capacity to allow easy admission and free exhaust.

27. The Base or Crankcase of an engine is required to support all the working parts, and should be so designed as to be sufficiently strong at all points where unusual strain is likely to be exerted. Base or Crankcase should be so designed as to carry cylinders, flywheel, etc., in the most simple, convenient, efficient and compact manner.

28. In some cases engines are mounted on a sub-base, which is detachable.

29. The least carelessness in the construction of the crank or bearings determines a partial or complete failure of the engine.

30. The edges or rather the inner edges of the bearings should be so dressed as to just admit the crank without practically any end play, and in a position to bring the center of the crank pin exactly in line with the center of the cylinder.

31. The brass or babbitt bearing should be so put in as to insure the center of the **Crank Pin** in its entire stroke to be in **exact line** with the center of the cylinder. In other words, the bearings must hold the crank shaft at perfect right angles to the cylinder centers.

32. The brass or babbitt bearings should always be strictly of the best material obtainable for the purpose. The least variation from perfect alignment means faulty construction.

33. The piston should be sufficiently smaller in diameter than cylinder to allow for heat expansion and contraction. It should be a close gray iron casting, free from sand holes. It should be of the drum-shaped variety, closed at one end and open at the other to receive the end of the connecting rod.

34. There is no rule governing the length and weight of a piston. Each manu-

facturer constructs a piston of length and weight after his own ideas.

35. The longer and heavier a piston the more friction in the cylinder, and consequently the more power is required to move it, and the more work will be thrown on the crank bearings and shaft in reversing it, which imparts an end motion to the entire engine that is difficult to balance.

36. Generally speaking, vertical engines admit of a shorter piston than the horizontal type, as the horizontal engine carries the weight of its piston on the cylinder walls. and the longer the piston the less damaging is the wear on the cylinder. The weight is distributed over more surface.

37. A vertical engine carries its piston weight principally on the crank shaft, and therefore should be as light and short as the force with which it has to deal will allow.

38. The Rings on the Piston serve to prevent the escape of the expansive force past the piston, which is necessarily somewhat smaller, so as to allow its free and easy movement in the cylinder.

39. Sometimes an additional ring is provided to assist in distributing the lubricating oil along cylinder wall.

40. Piston Rings are made of a high grade cast iron and of such size that when fitted around piston in the grooves pro-

vided for this purpose, the rings have a tendency to spring outward and fit snugly to the walls of cylinder.

41. If piston rings are not properly made there will be a loss of compression past the piston and consequently decrease of power. In the four cycle engine this is indicated by a coughing noise or smoke coming out of the open end of cylinder. Such indications cannot be noticed in two cycle engines however, owing to the crank case being closed. If examination shows that rings are bearing and worn only at the cut, it is evidence that the rings were not properly made and fitted.

42. The **Connecting Rod** which connects piston to crank shaft is generally cast iron, bronze, machine steel, malleable iron or a drop forging.

43. Connecting rod should be perfectly balanced, and made as light as possible.

44. **Crank Shaft**—The question of crank shaft construction is a very important one. The center line of the wrist pin should be exactly parallel with the center line of the crank shaft. The least variance from this necessarily makes a bad running engine.

45. In some cases, where bearing was running hot, it has been found that wrist pin was not only out of line with shaft, but also of different diameter at the ends, one end of the pin being con-

siderably larger in diameter than the other.

46. The throws of the crank shaft should be of exactly the same thickness, so as to bring the wrist pin in such a position that the center line of the cylinder will divide it into two exact halves in every part of the entire length of its stroke.

47. **Length and Diameter of Wrist Pin**—Wrist pin should be designed with sufficient factor of safety to withstand the greatest stress to which it will be subjected.

48. **Valves**—Four cycle engines always have two valves—an inlet and an exhaust valve.

49. In some engines both inlet and exhaust valves are mechanically operated by cams.

50. In others the inlet valve is automatically operated by the suction of the piston on its charging stroke.

51. All four cycle engines necessarily have cam operated exhaust valves.

52. In some cases both inlet and exhaust valves are on the same side and operated by the same cam; in others, inlet valve is on one side and exhaust valve on the other.

53. Cam shafts are generally driven from the crank shaft by geers and turn at half crank shaft speed.

54. Valve and seat should be in such a position as to be easy of access.

They should be examined and cleaned occasionally.

55. The exhaust valve on large engines is generally water jacketed. Where this is not done valve seat is liable to warp or scale under the excessive heat.

56. A valve mechanism may be so designed as to use alternately either gas or gasoline as fuel, but not both at the same time. A valve or set of valves may be arranged so as to shut off one and turn on the other, thus changing fuels without stopping the engine.

57. The conditions requiring such an immediate change are so rarely met with that I doubt the propriety of fitting an engine with such a complex arrangement. Where a change is really necessary there is always sufficient warning and ample time to prepare for it. The two fuels are of a different chemical composition, and the blending of their elements with a volume of air so as to make a ready explosive would be extremely difficult, and therefore impractical to attempt their combination or use in conjunction or at the same time.

58. To go into the details of describing the various fuel valve mechanisms now used would require more space than could be allowed in this little work. Each builder claims some superior point of merit in his method of feeding the fuel, but it should not be forgotten that other reliable builders may have

other points as good. It may be sufficient to say that the gas valves, and their operating mechanism, are generally so arranged as to open the valves when the outward movement of the piston is drawing a current of air into the cylinder and partly by the force of the gas pressure and partly by the suction produced by the piston the gas is admitted to the current of air and mixes with it as it enters the cylinder.

59. Gasoline valves and their methods of handling fuel are a little more complicated, but in most cases it is the current of air, also, by its suction power, that draws sufficient gasoline from a needle point or valve to charge the air current. In some instances the gasoline is forced into the air current by means of a small pump. Some kerosene engines take a charge of air only, and after compressing it, the kerosene is sprayed into the compression space and immediately fired.

60. A purchaser needs to familiarize himself with the function of the gas or gasoline valve on his engine and its method of feeding the fuel. It requires only a little close attention and common sense to learn in half an hour all that is necessary to know about the feeding and regulating the fuel to the engine.

61. The fuel may be properly fed and regulated and yet the engine refuse to go. Therefore the fellow who uses

common sense enough to learn the proper feeding of gasoline or fuel will get into trouble, if he concludes that he has learned it all. This is just the position in which many a fellow is found. And this brings us to that mechanical part of the engine which is probably more often the source of trouble than all others combined and that is **Igniting Mechanism.**

62. Various methods have been used to ignite or explode the charge of mixture within the compression space.

63. The most common method employed at present is the electric spark method consisting of an electric spark formed by means of electric current of sufficient intensity to ignite the charge, and occurring at just the proper time.

64. There are two kinds of electric spark ignition—the make and break or low tension system, and the jump spark or high tension system.

65. In both of these systems there must be a source of electric current, a method of interrupting the current at periodical intervals, and sparking points within the compression space, through which the spark is applied to the explosive mixture.

66. In the make or break system the spark is made by the breaking or pulling apart of two surfaces (ignitor points) within the combustion chamber, which have previously been in contact, in this way a closed circuit is suddenly opened, causing a spark to bridge across the intervening gap between the two points.

67. The mechanism that operates the movable point or terminal should be so designed that the contact will be of short duration, that the break or separation can be easily timed so as to make the spark earlier or later, that the terminals always remain separated between the act of sparking, so as to make a contact when the charge is compressed.

68. The movable contact point should approach the stationary gradually, press it firmly and separate instantly.

69. In the jump spark system the current is led from the source of supply to a spark coil, where it is transformed from its primary or low tension stage to a secondary or high tension stage.

70. From spark coil the current is led to a spark plug, screwed into combustion chamber, where the point of contact with the explosive mixture is made.

71. The current is interrupted and caused to occur at the proper time by means of a timer, usually operated from the crank shaft or cam shaft of the engine.

72. The current can be carried any reasonable distance through metal that is a good conductor or carrier of electricity. Of course it is always necessary before a current is made that there is a contact of the terminals or a con-

nection between positive and negative poles.

73. The electric terminals or contact points are therefore necessarily in the igniting chamber of the engine, and at least one of them must be insulated from that part of the cylinder wall through which it passes.

74. Platinum is the best metal to be used for sparking points, however irridium, meteor wire or high grade german silver wire is extensively used, although shorter lived.

75. The insulation of one of these terminals should be complete, practically indestructible and proof against heat and moisture.

76. The most commonly used materials for insulating purposes are porcelain and mica.

77. The spark is indirectly controlled by the governor on some engines. Usually the governor controls the exhaust or inlet valve movement, and this valve movement is made to incite the movement of the sparking mechanism only when a charge is taken into the cylinder. On other engines no attempt is made to govern the number of sparks at all, but a regular succession of sparks occur whether the governor admits a charge or not.

78. **Governors**—The type of governor mostly used at present is the centrifugal or ball type, which is very simple and

thoroughly efficient in controlling the speed of engine.

79. No governor of the hit and miss pattern should act sluggishly, but should be sensitive enough to avoid two charges in succession when the engine is running without a load. One impulse should be sufficient to drive the engine over from one to five misses, owing to the speed of the engine. The lower the speed the fewer number of impulses allowed by the governor on an empty running engine. The higher the speed the more impulses.

A governor that cannot be made to throw off the succeeding charge after an impulse on an empty running engine should be rejected.

80. To be more explicit, a hit and miss governor that allows an empty engine two, three, four or five impulses in succession, and then throws off as many or more, certainly cannot be recommended unless it can be adjusted to do its work properly.

81. A good governor will handle an empty engine at, say, three hundred revolutions per minute, one on and two off. In other words, one impulse and two misses; at two hundred revolutions, one on and four off.

82. I consider the throttling governor a success. It is generally conceded by builders that the hit and miss governor is the most economical in fuel consump-

tion, but I do not regard it as necessarily so. The American inventor, if he has not already done so, will invent a method of injecting the fuel in such exact proportions as to give the proper strength to the impulses to carry a uniform speed under a variable load, and at the same time use only the amount of fuel necessary, and therefore reduce the fuel consumption to the minimum.

83. There can be no question of the advantage the throttling governor has over the hit and miss governor in point of steady power. The principal objection to the hit and miss governor is the variable speed it imparts to the engine.

CHAPTER III

INSTALLATION AND EQUIPMENT

84. **Setting a Stationary Gas Engine**—Many purchasers fail with the gas engine because of their desire to install it with the least possible expense.

85. This is a great mistake. After buying a gas engine one should go to the expense of installing it properly.

86. If the engine is stationary, it should have a closed room, if possible, all to itself, free from dust and with plenty of light.

87. Too frequently we find purchasers placing their gas engines in some dark corner of the building or in some old damp cellar that has been abandoned on account of its unfit condition to be used for any other purpose. They argue that if "I can use it for my engine I save space, and, therefore, economize." This is surely false economy.

88. I insist that if the purchaser decides to use such abandoned space in which to locate his engine he would at least save time and money by going to the expense of partitioning the space off into a room large enough for the engine, and keep

on until he has transformed his engine-room into the snuggest, neatest, cleanest and most convenient spot about his building, and then see that it is kept in that condition. Why not? The engine is surely the head of his machinery plant, from which he expects to derive a profit. When the engine stands idle all his machinery is idle. He can make his engine a source of profit or loss just as he will give it good or bad treatment.

89. **The Foundation** should be in keeping with everything that is good and substantial. Bolting the engine fast to "any old floor" is bad practice. But, alas! Gas Engines are advertised to set anywhere, on any floor or in any cellar. There are foolish advertisers as well as foolish purchasers. A careful purchaser will not buy of a reckless and careless advertiser who makes unreasonable or extravagant claims for his engine.

90. Every stationary engine purchaser should figure on a stone, brick or cement foundation if at all practicable. If nothing but a floor foundation can be had, good heavy timbers should be bolted to the floor, of sufficient length to strengthen the floor for a considerable distance around the engine, and the engine bolted to these timbers.

91. The only object in a foundation is a solid setting for the engine. If you haven't got a solid foundation you

might properly say you have no foundation. A good engine room and a good foundation is an excellent beginning.

92. The depth of the foundation below grade line depends somewhat on the condition of the soil. It should always go below the freezing line and as much below as is necessary to get a firm base. Ordinarily from three to four feet is sufficient for small engines from four to twelve horse power. Larger sized engines from 15 to 40 h. p. from four to six feet is not too much.

93. **Dimensions of a Foundation.**—A good rule is to make the length of the foundation in the bottom twice the length of the engine base. The width in the bottom may be two and a fourth times the width of the engine base. The foundation should be brought up on a batter or incline from the bottom to the floor line or level of the ground.

94. It should then be covered with a capstone from eight to twelve inches thick, according to the size of the engine. The foundation may be capped with good, heavy timber where a stone can not be conveniently had. You understand, of course, that it is always desirable to have the capstone or timbers from two to six inches wider than the engine base and from six to twelve inches longer, so that when the engine is placed on top the cap extends beyond the engine base from one to three inches on each side,

say one inch for a 4 h. p. and three inches for a 40 h. p.

95. The height of the foundation and capstone above the ground level or floor line should be sufficient to clear the fly wheels or prevent them from hanging to the floor by from two to three inches.

96. A concrete foundation, if properly constructed, is the best. While foundations are usually built of brick or stone laid in cement a foundation may be of concrete, mixed as follows: One part of cement, two parts sand, five parts finely cracked stone or coarse gravel is first class. Foundations built with frozen mortar or concrete are no good. Avoid freezing weather while building your foundation.

97. **Anchor Bolts.**—The number and size are usually determined by the builder of the engine and indicated by the holes he drills into the engine base to receive them. They should be long enough to extend from the bottom of the foundation to from two and a half to four inches above the capstone or timber.

98. They should be screwed into good-sized iron anchor plate at the bottom and threaded on top to receive a nut. An anchor plate six to eight inches wide and ten to fifteen inches long with a hole in the center tapped out or threaded, into which the rod is screwed and riveted, makes an excellent anchorage.

99. It is regarded good practice when setting the anchor bolts before building the foundation to set the anchor plates on small base stone or solid wooden block as large or larger than the anchor plate. Also to slip a piece of iron pipe (with an inside diameter an inch larger than the rod) over each bolt. This pipe should extend from the anchor plate to the top of the foundation, but not to the top of the rod.

100. **A Templet** should be made with holes the exact diameter of the rod, and distances between them exactly as the holes in the engine base. The nuts are then run on to the top of each bolt down far enough so as to let about two inches of the bolt extend above the nut. The bolts are then set in position and stayed at the top by slipping the top of each into the corresponding hole in the templet, the nut serving as a rest for the templet. Line up the bolts with the line shaft or building, stay the templet in that position and proceed to build the foundation around the bolts.

101. After the foundation is completed and it is determined that each bolt is in exact position to enter the corresponding hole in the engine base, the pipe around the bolt may be filled with slush cement, which when set will stay the bolts firmly.

102. Three or four days after the foundation is completed, and the cement firmly

set, the engine may be placed in position and bolted down for work.

103. **Lining Up the Engine** with the shaft, and vice versa, is of the utmost importance, and it should be done just right, if the drive belt is expected to run true and give good service. Therefore if the line shaft is in position it is well to take the precaution to see that the drive pulley on the engine and the drive pulley on the line shaft are in line before bolting down the engine.

104. This is done by stretching a chalk line from the extreme outer edge of both line shaft pulley and engine pulley. Then shift the engine to such position that the inner edge of both pulleys also touch the line.

105. A better way is to line the engine shaft with the line shaft as follows: Drop two lines from the same edge or side of the line shaft as far apart as the length of the engine shaft. Drop the weight on end of each of these lines into a pail of water on the floor to keep them from swinging. Then measure with tape line, or, better, with pole, from each line to the center on each end of engine shaft. These distances should measure exactly alike.

106. **Piping or Connecting Up an Engine** consists of piping up the fuel, piping away the exhaust and piping water to and from the engine, if water is used for cooling purposes, and it is prac-

tically used for cooling all stationary engines up to the present time.

107. In making the **Water Connections** pipe of the size indicated by the ports in the water jacket should be used unless hydrant water is employed under pressure, then smaller pipe may be used.

108. Valves should always be fitted into the pipe line so as to allow shutting the water off for drainage purposes.

109. When a cooling tank is used the valves should be as near the tank as they can be placed, so that the pipes leading to the engine can be drained.

110. A pipe with a valve and union should lead from the lower part of the tank to the threaded inlet port, somewhere in the under part of the water jacket of the engine, and a pipe from the outlet port in the top of the cylinder or jacket to the top of the tank.

111. The water passes from the tank to the engine through the lower pipe, and as it becomes heated it rises into the upper pipe and flows back into the top of the tank.

112. This circulation is caused by one of Nature's laws. Cold water is heavier than hot water, and as the cylinder heats the water it gets lighter and the cold and heavier water naturally crowds in below and forces the heated water through the upper pipe to the tank.

Therefore the hottest water is always at the top of the tank.

113. **Pipe Connections for the Use of Hydrant Water** are as follows: The inlet pipe from the hydrant to the same point on the engine as in the tank system, with valve and union to guard against freezing by draining the cylinder and pipes attached.

114. The overflow pipe from the top of the cylinder should be led into a waste trough or pipe somewhere in such a manner as to expose to view the stream of water leaving the engine.

115. The pressure from a hydrant is often sufficient to force too much cold water through the water chamber, keeping the cylinder too cool and resulting in a loss of power. The valve in the inlet pipe should be used to throttle the stream to the engine.

116. Where a very limited quantity of water only can be allowed, as in portable engines or automobiles, a circulating pump and fan are sometimes used.

117. **Pipe Connections for Fuel in a Gas Engine** are: Regulator, gas bag, valve or stop cock and piping of the proper size to meet the requirements of the engine.

118. Where natural gas is used for fuel it is always desirable to use a **Regulator.** However, we find purchasers who prefer to run their chances of having all

kinds of trouble with their engine, which a gas regulator would obviate, rather than go to the expense of putting in a gas regulator. It is needed where gas pressure is liable to vary.

119. Either the gasometer or one of the many diaphragm and valve regulators may be used successfully, provided they allow a sufficient volume of gas at low pressure, say, for instance, not to exceed eight ounces to the square inch.

120. The stop cock and regulator are connected into the pipe from the engine in the order named, first, a short nipple of pipe, say from four to six inches long, is screwed into the inlet port on the engine, onto it the stop cock, then another piece of pipe and finally the regulator.

121. **The Gas Bag** may be a good rubber bag made completely of rubber, or it may be made of an iron frame with rubber diaphragm such as some engine builders use.

122. When gasoline is the fuel there are two common methods in use for bringing the gasoline to the engine, namely: The Pump and Gravity Systems. The **Gravity System** consists of piping the elevated supply tank to the engine and letting the gasoline into the engine through suitable valves. In this method gasoline is supplied to the engine by its own weight or gravity.

123. **Fittings for Gravity Method**—If the

gravity method is used, there is an inlet valve on the engine usually reinforced by a needle valve. The supply pipe is connected from the inlet port on these valves to the supply tank, which should be elevated somewhat above the engine.

124. The arrangement of **the Pump System** consists of a small pump fitted to the engine which is designed to be piped to the supply tank outside of the building, and to draw the gasoline from the tank and force it into the Mixer of the engine as it needs it.

125. The supply tank in this instance is located somewhere from three to six feet below the engine, and an overflow pipe is connected to it from the engine for the purpose of returning to the tank any over supply that may be forced up by the pump.

126. There is a pipe connection between the lower part of the supply tank and the suction port or valve on the pump, and an overflow pipe from the mixing or supply cup of the engine to the top of the tank. The tank is so placed as to allow drainage of all the gasoline in the pipes, back to the tank when the engine is not in use.

127. From ¼ to ½ inch pipe is used ordinarily, according to the size of the engine.

128. Fire Insurance Companies require the pump system, with the tank placed a certain distance away from the building.

But the gravity method is just as effective in supplying the engine with fuel and has the advantage of less mechanism to get out of order. Of course good threaded pipes and absolutely tight joints should be insisted on in these pipe connections for gasoline.

129. **Exhaust Connections.**—When an engine is installed in a building the real object of exhaust pipe connections is to get the burnt gases and the noise from the exhaust outside of the building. And inasmuch as the noise is very undesirable in many localities, it is the custom of nearly all engine builders to supply, with their engines, a large Iron Drum, into which the pipe from the engine is connected and which serves as a muffler to the exhaust reports.

130. **Mufflers** of different kinds are used on portable and automobile engines. They are usually arranged to screw onto the end of the exhaust pipe and consist of an iron casing, enclosing a series of small cavities, which are freely connected with the inlet and also with the many small openings which serve as an outlet. The object in such a muffler is to break the force of the exhaust pressure and let it into the open air through many small openings.

131. **Piping the Exhaust Into a Flue or Chimney of a Building.**—There may be very serious objections urged against this practice. Unless the flue has a

large caliber, with a good draught, it should not be considered at all.

132. There is always more or less experimenting necessary where an inexperienced hand is learning to run a gas engine. And he may turn the engine over, admitting charges and forcing them out of the exhaust pipe into the flue a number of times before igniting one of them, and when the ignition does occur, the flue is charged with gas, which lets go with such force as to wreck the flue and sometimes the building.

133. The sooner gas engine builders and purchasers get the idea out of their heads that "any old thing" is good enough the better it will be for every one concerned.

134. Piping the exhaust into a well or cistern if properly done is all right. I should suggest, however, in such instances that before it is done it is known that the water never rises to a point to interfere with the exhaust.

135. In fact, to be on the safe side the entire space in the cistern or well should be free from water at all times. A good tight cement covering with a good sized vent should be arranged.

136. A box two by four feet buried in the ground endwise and filled with clean pebbles or stones in sizes from that of a hen's egg to that of a man's fist makes an excellent muffler for an engine up to

25 h. p. The exhaust pipe should, of course, be led into the lower part of this muffler and water excluded at all times.

137. A box two feet square inside, ten feet long, made of heavy (two inch) plank, without bottom, buried in the ground, and the exhaust from the engine piped into one end, and a short pipe from the other end as a vent, makes a very effective muffler. No stone is used in this box—just the hollow in the box with the ground floor. The entire box should be buried to a depth of two feet.

138. The exhaust connections are simply a pipe of the proper size leading from the exhaust valve port to the exhaust drum and from another port in the drum to the outside of the building, or underground muffler if one is used, and thence to the outside.

139. It is well to place the exhaust drum as near to the engine as possible and get to the outside of the building by the shortest convenient route. Long exhaust pipes have no tendency to improve the running qualities of the engine.

140. The end of the exhaust pipe should be left free and open, where an exhaust drum is used, except that it is good practice to screw a "T" onto the end of the pipe and a short nipple into each end of this "T," which serves the double purpose of protecting the pipe from snow, rain and ice, and relieves the ex-

haust by two openings instead of one.

141. For the purpose of explaining more fully, I wish to modify my previous statement against the use of long exhaust pipes. The advice is proper with practically all engines built in this country up to the present time.

142. **Scavenging Engines.** — Plausible claims are made for the scavenging engines, some of which are coming into use. The object of scavenging is to free the clearance space or combustion chamber from burnt gases each time before another fresh charge is admitted.

143. It is recommended that an exhaust pipe of sufficient length and proportions will cause a succession of waves in the outward rush of the exhaust gases, which tend to create a partial vacuum in the clearance space, and thereby practically free it from burnt gases. I will not go into detail of the scavenging engine, as practically all are non-scavenging up to the present time, and there is no indication of the scavengers coming into immediate use, in America at least.

144. **Tube Ignitor.**—The tube ignitor consists of a **Tube** closed at one end and threaded and open at the other, a cast iron chimney, a gas or gasoline burner, pipe connections from the gas supply to the burner or to a small gasoline supply tank elevated five or six feet.

145. The tube is anywhere from five inches to twelve inches long and from ¼ to ⅜

inch in diameter. It is made either of common gas pipe or nickel alloy, sometimes called composition tubing. The threaded and open end of the tube is screwed into an opening which communicates with the interior of the cylinder or firing chamber. This makes a continuous passage from the combustion chamber up in the hollow of the tube to its closed end.

146. It is intended to keep this tube at a red heat while the engine is running. This is done by means of the cast iron chimney, which is fitted on so as to entirely enclose this tube, and a burner fitted into the lower part of this chimney so as to direct a jet or Bunsen flame against the lower end of the tube.

147. The top of the chimney may be capped with numerous small vent holes in the cap. The inside of the chimney is lined with asbestos sheet, the object of which is to retain the heat and confine the flame immediately around the tube as much as possible.

148. The burner should be so constructed as to deliver a bright blue flame around the tube, which should become heated to a cherry red heat in from three to five minutes after it is lighted. The burner is usually fitted with a valve with which to control the flame, but the pipe connections from the burner to the gasoline supply tank or to the gas supply, should contain a valve

as a means of shutting off the full supply from the burner when the engine is not in use.

149. The object in elevating the gasoline supply tank is to give sufficient pressure at the burner or generator to throw the jet of gas with some force against the tube.

150. The point in the length of the tube at which the flame should be directed depends on the compression pressure in the cylinder. If there is a high compression pressure the firing point on the tube should be naturally higher up because the fresh charge forces its way higher up into the tube on a high than on a low compression.

151. You understand that the tube always remains filled with burnt gases when the ordinary tube igniting engine exhausts the burnt charge. The fresh charge then has to crowd up against this burnt gas in the tube, which serves as a cushion, and drives it into the upper part of the tube until the fresh gas meets the red-hot part of the tube, when ignition occurs. You will therefore see that if the compression in an engine is light it can not force the fresh charge as high into the tube, and consequently the tube should be heated lower down.

152. Some builders are now making adjustable chimneys, to which the burner is fastened, which can be moved up or down and fixed so as to direct the flame

against any point on the tube to suit the compression.

153. What would I do if I had an engine with a fixed flame point? I should try tubes of different lengths until one was found that gave the best results. If pre-ignition occurs it may not be possible to correct the trouble by changing the length of the tube, and something must be devised to raise the flame point higher on the tube.

154. **Electric Ignitor.**—The electric igniting outfit consists of a **Spark Coil,** a **Current Breaker** or **Switch,** from fifteen to forty feet of insulated copper wire, about No. 14, a battery or small dynamo, which generates the current, and the sparking mechanism on the engine, which has already been described.

155. **The Spark Coil** is a bundle of soft Iron Wires, cut all the same length, anywhere from five to ten inches long. The ends of this bundle of wires are inserted into a round hole, in a small block of wood, of just the exact size to receive all the wires and hold them firmly together in the shape of a round bundle.

156. This bundle is covered with a sheath of pasteboard, around which is wrapped closely and evenly from end to end between the blocks successive layers of one continuous piece of insulated wire. The two ends of this insulated wire

are fastened to separate binding posts which are mounted on one end of the blocks. These blocks are then screwed firmly to a small base board, so as to hold all parts of the coil firmly in position.

157. It serves the purpose of resistance to the current, without which an igniting spark can not be made.

158. If the length of insulated wire is properly proportioned to the bundle of soft wire the coil also serves to allow a shorter contact of the terminal points, which in turn saves waste of current and wear of the points, which are both items of considerable expense if not carefully guarded. A short coil four to six inches long meets all the requirements.

159. **A Switch** is simply a block of wood or porcelain mounted with two binding posts and a connecting lever, which is permanently connected to one binding post and may be connected or disconnected with the other binding post at will.

160. Its purpose is to switch the current on to the engine for work or to cut it out and insure against short circuit when the engine is not in use.

161. **Electric Connections** to the sparking device on the engine.—One end of the wire which is to carry the current should be connected to the binding post on the insulated terminal or electrode,

the other wire is attached to the other binding post, which is usually placed at some convenient point on the engine by the builders.

162. If there is but one binding post supplied on the engine, then the second wire may be attached firmly to any bright point on the engine which is convenient, or it may even be fastened around one of the gasoline or water pipes if they are not painted.

163. The insulation must always be stripped off the end that is to be fastened and the connection made with the bare end of the wires.

164. The wire from the insulated terminal binding post is then carried to the spark coil and connected to one of its binding posts. From the other binding post on the spark coil a piece of wire is carried to the first cell of the battery and connected to its positive or carbon binding post or to the same on dynamo.

165. This makes one connection between the engine and the battery or dynamo, whichever is used for ignition purposes.

166. Another wire is carried from the negative point on dynamo, or zinc binding post on battery, to one of the switch binding posts, and from the other switch binding post to the engine. The switch may be fastened at some convenient place on the wall.

167. The two wires from the battery or dynamo to the engine, one containing

the coil and the other the switch, completes the circuit.

168. **In Connecting the Battery** all the cells between the first and last must be connected up in a series with short pieces of insulated wire, as follows: From the zinc binding post on the first cell to the copper binding post on the second; from zinc on second to copper on third, and so on until all are connected.

169. If a **Fluid Cell Battery** is used it must be charged, which consists of first making a solution with the chemical used for that purpose and soft water. After each cell is nearly filled with this solution the metal bases, such as zinc and carbon, which are usually attached to the lid of the cell, are lowered into the solution in the cell. Then it is ready to be connected up in the series. All fluid batteries are accompanied with instruction sheets.

170. It has been the general custom to use fluid batteries, but several **Dry Cell** batteries have recently been introduced which bid fair to become a formidable rival of the fluid cell.

171. There are also the little **Sparking Dynamo** and **Magneto**, which are successfully used in many instances for gas engine ignition. Also the **Hot Tube.**

172. There are so many points to be considered in this connection that it would not be fair to our readers to attempt to

recommend either device above the other.

173. The ignition of a gas engine is a source of repair expense, no matter what source of electrical energy is used. Each arrangement has its disadvantages as well as its advantages. Economy, safety, attention, convenience, cleanliness and reliability are the principal points to be considered.

174. The location and surroundings would probably determine my preference. For instance, in the natural gas fields, where fuel is very cheap, I might decide on the hot tube ignition. Away off in the country where gasoline is the fuel and somewhat expensive, I think a good dry cell battery would about meet the conditions. In the city where electricians are to be easily had when repairs are necessary the magneto or dynamo would, in my opinion, more nearly meet the requirements. The fluid cell is a sort of mother over all the others because it has been most generally employed in this country.

175. By the foregoing statement I do not mean to convey the idea that the fluid battery is more desirable than the others, only that it holds sort of a preempted claim now by reason of having been more generally used in the past.

176. I wish to make this assertion, that I can operate a gas engine successfully on either method of ignition anywhere,

with economy possibly in favor of the dynamo if it is well constructed, but it may require more attention than the battery. (See special chapter on Dynamo and Magneto Ignition.)

177. Either method, as before stated, has its advantages and disadvantages, and my advice to my readers is, that, whichever method you may be called upon to use, inform yourselves as quickly as possible on its disadvantages, and overcome them as nearly as possible.

178. I doubt not that the reader now thinks we have reached the point of starting the engine and is anxious "to see the wheels go round." But you will be more highly delighted in seeing them turn if you have first learned and attended to all the preliminaries. A good engineer never omits one of them; a bungler omits all of them.

179. These **Preliminaries** are **Arrangement, Cleanliness, Water, Oiling.** Under arrangement comes the old adage, "A place for everything and everything in its place." The condition of the engine room portrays the character of the person in charge. A **Bad Running Engine,** waste, wrenches, oil cans, litter in general scattered promiscuously over the floor of the engine-room indicates a bungler not worthy the name of engineer.

180. An engine-room with plenty of light, everything in apple-pie order, trim,

clean and neat, means a nice running engine and a For-Sure Engineer.

181. Cleanliness contributes so much to the successful running of an engine that it can not be **Too Firmly Impressed** on the mind. The companion of cleanliness is **Plenty of Light.** Darkness and dirt go hand in hand.

182. Therefore with plenty of light in the engine-room it should be cleaned up and made as free as possible from dust and grit. After this the engine should be thoroughly cleaned all over, giving special attention to the Cog or Spiral Gears, governor, valve stems and valve cams. On account of dampness these working parts often become rusted in shipment, and will not work properly until cleaned.

183. The water supply should be noticed to see if the tank is full to the overflow pipe, and in cold weather to see that none of the pipes are frozen up.

184. Then comes the oiling of the engine, which should be done in a thorough manner. It is well to use the same grade of oil recommended by the manufacturers of the engine, and to follow their instructions to the letter as to the method of application.

185. Steam cylinder oil is not well adapted to a gas engine cylinder. A light thin cylinder oil, of a high fire test, is best adapted to use in the gas engine cylinder. It is usually much less expensive

than heavy steam cylinder oil. Some gas engines are fitted at the wrist and journal boxes with grease cups, which should be filled with shafting or graphite grease and set so as to feed automatically.

186. When oil and grease cups are filled and all bearing parts that are liable to wear are oiled, the **Valve Stems** should be tried by lifting the valve pallet from its seat a number of times after squirting some kerosene oil on the stem from a squirt can. These stems should be frequently examined and kerosene oil used only occasionally to keep them clean. Never use ordinary lubricating oil on them. The heat simply burns it and leaves a gummy deposit on the stem which interferes with the free movement of the valve.

187. **Starting is Next in Order.** Practically all the small-sized engines from two to ten-horse power are started, as it is called, by hand. Some engine builders fit their engines over ten h. p. with a starter, which, in some instances, is more alluring to the purchaser than practical.

188. The first act in starting a gas engine by hand after switching in the battery current is to get a charge of gas and air, properly mixed, into the cylinder. This is accomplished by opening the gas or gasoline valve slightly so as to admit a small portion of the fuel as the

receiving valves are opened when the fly wheels are turned over at a rapid rate.

189. The majority of gas engines are fitted with a priming cup. When engine is just started after standing idle, or when it starts hard, it should be primed by pouring a small portion of gasoline into the priming cup. The engine receiving its first two or three impulses from the fuel in the priming cup, which gives it sufficient momentum to keep it going until the regular mixture comes into the cylinder.

190. You have no doubt heard persons say that they have to turn their engine for half an hour or more before they can get it going. If such persons knew that they are simply proclaiming their astounding lack of judgment they would not be telling it.

191. But, you say, if the engine fails to ignite its first, its second and its third charges, is it not policy to keep turning the wheel until it does ignite? If neither of the first three or four charges are ignited the cause of non-ignition will not be removed by turning the wheel, and will probably be getting worse the longer you turn, and the fellow who does not know what else to do but turn ought to be compelled to turn vigorously until his tongue hangs out of his mouth to the length of a full-grown lead pencil. If such exertion

doesn't start his thinker, his case is probably hopeless.

192. If an engine doesn't ignite its first charges there is a cause for it, and no amount of turning will locate it, but a little common-sense thinking will not only locate but remove the cause, and the engine will do its own turning after the first two or four revolutions.

193. You would like to know why I say four. If common sense will do it, after allowing one revolution to admit the charge and gain the momentum, why not always start or ignite the second revolution? There is no such thing as absolute perfection even in common sense, but four, and occasionally six, revolutions for ignition may come within the bounds of practical perfection. However, I know of many gas engine operators who seldom turn the wheel more than the second time.

194. The engineer who knows his lesson well will know that there are many improper adjustments and irregularities that will cause failure of ignition on the first turn, and will avoid them, and as they are of sufficient importance to require special attention we had better finish starting the engine in a normal condition and take this subject up later.

195. **Turning over Compression Point.** Nearly all engines are provided either with a relief valve or a shifting cam or lever, which makes a relief out of the

exhaust valve. By means of these valves only the latter part of the compression stroke serves the purpose, inasmuch as the former part is relieved by an open valve. This allows sufficient compression to start with and makes resistance at this point barely perceptible in turning.

196. Others prefer to inhale a charge by a one-half turn of the wheel on the outward movement of the piston, then by disengaging the receiving valve lever from its cam a rapid backward movement of the wheel and the piston compresses the charges, and fires it from the tube ignitor, or the electric spark, by snapping the sparker quickly by hand while on compression.

197. The ignition of this charge drives the piston rapidly forward and gives the wheels sufficient momentum to carry several revolutions and catch the next charge.

198. Where a relief lever cam or valve is used the impulses are necessarily light while the valve is relieving the compression, and the lever should be shifted and the valve closed as soon as the wheels have gathered sufficient momentum to carry over the full compression.

199. Instead of having the engine inhale its own charge by turning the wheel, some builders fit their engines with a small **Hand Air Pump** for the purpose of pumping the first charge into the cylinder. The air thus pumped passes through a receptacle containing gasoline, which serves as a carbureter and charges the air sufficiently with gasoline to make it explosive. After the cylinder receives its charge from the pump, the valve in the pump connection is closed, and the wheels backed up on compression, the charge is fired as before described, or by means of a match ignitor.

200. **The Match Ignitor** consists of a little tube containing a plunger and closed solidly at one end except two side notches near the end, and fitted at the other end with a packing gland through which the stem of the plunger extends to the outside. The end of this stem is fitted with a button.

201. The tube being threaded is screwed into a port into the cylinder walls and the notched end of it extends into the combustion chamber.

202. The head of the match is placed under the plunger and the button tapped with the hand, dashing the plunger down onto the match head, and the resulting flash ignites the first charge in the cylinder through the side notches in the tube.

203. A somewhat different device is used by some engines, but the principle is the same exactly.

204. You of course understand that this is used only for igniting the initial charge, and consequently is only a starter.

205. The compressed air starter consists of a tank with a capacity two or three times that of the engine cylinder, and an air pump, which is driven usually by a belt from the line shaft, filling the tank with air to a pressure of from sixty to one hundred pounds, which is indicated by a pressure gauge on the tank. The tank is filled when the engine is running and held ready for the next start.

206. The pipe leading from the tank to the compression chamber in the cylinder is fitted with a handle valve that can be manipulated quickly.

207. When ready to start, the engine is set with the piston back in the cylinder, the crank shaft about two inches above the inner center, and the valves closed. Of course the cylinder valves must remain closed on the first outward movement of the piston.

208. When the engine is set already to receive the charge from the tank and the battery current switched on ready for ignition, the valve between the engine and tank is quickly opened, throwing the pressure from the tank into the cylinder, which drives the piston forward. By closing the valve at the end of the piston stroke the act may be repeated at the second revolution following, giving impulse sufficient to catch a charge of gas and air with the ignitor on the third or fourth revolution.

209. This compressed air starter is only used on engines above 15 h. p.

210. The same arrangement with a smaller tank and much less pressure can be used successfully by fitting a little cup, for the purpose of holding gasoline, into the pipe between the tank and engine, and as the air rushes from the tank into the cylinder it is charged with gasoline and may be exploded by the Electric Spark or igniting mechanism.

211. The Compressed Air method seems the most practical for starting larger sized engines. While it makes the first cost of an engine higher, it is well worth its price to the purchaser.

212. It is supposed, of course, that an engine will run all right after it is once started, but it doesn't always do it. You should run an engine for at least a half hour without a load when starting it the first time. This will give you an opportunity to get familiar with it, running empty.

213. If it is receiving its fuel in the proper proportions and the ignitor is working all right it will go right up to its normal speed within a few seconds after starting, and if it has a hit and miss governor it will cut out or miss three or four charges to every one it takes.

214. If it runs along this way at a "merry clip," taking only one charge in three or four and firing every charge it takes,

you can rest assured that it is ready for work.

215. But if there is a popping or back firing into the inlet pipe something is out of order with the carburetion or ignition system.

216. **Too Much Fuel** is indicated when there is smoke issuing from the exhaust pipe and when the charges that are taken are not all ignited.

217. You can shut down a gas engine by feeding too much fuel just as readily as by not giving it enough. A little judgment here will tell any one when he is feeding the fuel properly.

218. It is a mistake to turn on **More Fuel When More Power** is wanted. When an engine is pulling nearly its full load it is cutting out only about one charge in five or six. By listening closely to the sounds made by the engine and at the same time noticing it closely you will be able to judge whether it is running properly or whether it lacks the energy it should develop.

219. The **Compression** has much to do with the power developed. Compression may be lost so that the engine will develop but very little more power than to keep itself in motion.

220. About thirty per cent. of the entire cylinder volume should constitute **Compression Chamber.** If a high compression pressure is desired twenty-five or even twenty per cent. is allowable.

221. You understand that it is necessary in figuring up cylinder volume to consider all the valve and port space, which is practically a part of the cylinder. The principal objection to a high compression is the danger of premature firing of charges under a full load, which is due to auto-ignition, a result of high compression pressure.

222. **High Compression** is sometimes, but by no means always, the cause of premature firing. In fact, I might say that it is one of the rare causes, because very high compression engines are rare.

223. **Premature Ignition** may be caused by one thing in one engine and an entirely different thing in another. Probably the most common cause is some projecting point of iron in the combustion chamber that becomes red hot, which serves to ignite the charge, similar to a heated tube.

224. An improperly proportioned mixture, resulting in a slow combustion, may be so slow as to be still burning when the next charge is admitted, and then the new charge will be ignited just as it is entering the cylinder and fire back through the receiving pipe.

225. Little chunks of burnt carbon, accumulating from the burnt cylinder oil, in the combustion chamber, may constantly remain heated to the ignition point and ignite the charges prematurely.

226. Points of carbon deposited on any projection in the combustion chamber will do the same thing. It is therefore necessary to occasionally clean out the gas engine cylinder.

227. **A Constricted Exhaust** passage may retain a higher degree of heat in the cylinder and thereby assist in maintaining an igniting heat on some projecting point in the combustion chamber. But there is a power significance to valves and their passage that should determine their size and areas.

228. In four cycle engines, constricted valve passages may be a hindrance to the development of power. The valve proportions should always be carefully figured from piston speed and cylinder area.

229. The receiving valve area should be such as to give the ingoing gases a speed of from 95 to 110 feet per second. The exhaust gases should leave the cylinder at from seventy-five to eighty-five feet per second at atmospheric pressure.

230. The exhaust should be larger than the inlet valve, because at the moment of opening the exhaust valve there is a pressure of from twenty-five to thirty-five pounds in the cylinder to relieve, and consequently the rush of exhaust gases at the moment of release is away above 110 feet per second, and if it had to pass through a constricted valve passage it would maintain the initial high speed throughout the exhaust stroke of the piston, resulting in a piston pressure on the entire exhaust stroke.

231. The point, then, is to figure the exhaust passage of such proportions as to relieve the exhaust gases at an average speed throughout the exhaust stroke of not over 100 feet per second. I regret to say that it is common practice among manufacturers in this country to make the valves and their passages too small.

232. In a number of engines I had the privilege to examine, manufactured by different concerns, I found either a constricted cylinder port or valve area, or both.

233. It is the height of folly to have a good big cylinder port, and choke the passage with a "measly" little valve, or vice versa.

The passage should be of uniform area and of ample capacity from the cylinder port to the end of the pipe.

234. The manufacturer who will not figure these valve areas carefully of sufficient capacity, is cheating his engine out of a reputation and his customer out of power.

235. **Timing the Valves.**—The movement of the valves should be timed to give the proper results. This is an important point for all gas engine operators to remember. The valve cams on a

four-cycle engine are usually driven by the two to one gear fitted onto the crank shaft, and if for any reason the gears are taken apart and put together, even if only one cog out of place, it will throw the valves and sparking arrangement out of time.

236. Manufacturers usually mark **A Tooth** or **Cog** on one gear and its corresponding groove on the other with the same mark. These marked points should always meet, and the engine is then properly timed. You can, of course, easily understand how a cam and cam roller may become worn by constant use so as to throw the valve out of time. A worn condition means lost motion, which results in opening the valve too late and closing it too early.

237. You can test an engine to know if it is properly timed by turning the wheels over slowly and noticing at what point the valves open and close and where the igniting points separate.

238. The **Receiving Valve** should open at the beginning of the outward stroke and close at the end of the same stroke. The next inward stroke is the compression stroke, when all valves should be closed.

239. The **Sparker Points** should separate and make a spark just before the end of the compression stroke is reached. This is done to allow for the instant of time between the making of the spark

and the resulting combustion. The force of combustion does not come instantaneous with the making of the spark. Therefore the compression stroke will have ended before the force of combustion really begins, and the piston just starting on its outward stroke receives the full expansive force of combustion.

240. If the spark were made just at the end of the compression stroke actual ignition or expansion would not occur until the piston had traveled probably a fourth of its outward stroke. This delayed combustion could not be as effective as if occurring at the very beginning of the working stroke.

241. The **Exhaust Valve** should open when about five-sixths of the working stroke is completed, so as to relieve the cylinder to something near atmospheric pressure at the end of the stroke. The exhaust valve should then remain open for the entire exhaust stroke, and should close just as the receiving valve is again opening.

242. Again I think it proper to refer to the question of lubricating the valve stems of the gas engine. The work an exhaust valve is designed to do makes lubricating impracticable. The heat passing through the exhaust valve will quickly destroy the lubricating qualities of any oil, and therefore it makes it useless.

243. It is therefore the custom of gas engine builders to make no provision for valve lubrication. They can be operated successfully without oil. Before starting a new engine squirt some kerosene oil on the stem and see that it moves freely. A good grade of powdered graphite used on the valves and valve stems occasionally would tend to improve their working qualities.

244. All frictional parts should be regularly lubricated. But the wrist pin and cylinder need to be especially looked after. The oil cups supplying these parts should be noticed often during a day's run to make sure that the oil is supplied and properly distributed.

245. Insufficient lubrication of the cylinder is often indicated by a peculiar blowing, barking noise in the cylinder at each impulse. It is due usually to a dry piston allowing the force of combustion to pass the rings. It can often be overcome by adjusting the lubricator for a freer oil supply without stopping the engine.

246. After running a cylinder dry, at the first opportunity the piston should be taken out, and the rings, their seats and the entire piston thoroughly cleaned. At the same time the cylinder and combustion chamber should be examined with a lighted candle and cleaned from chunks of burnt lubricating oil and deposits of carbon in the

form of soot. This is also a good time to clean the valves and valve ports, as well as the igniting apparatus.

247. Before the piston is returned to the cylinder it should be lubricated with oil. A good engineer will seldom have this to do, because he will see to it that his cylinder is lubricated.

248. The wrist should run cool. If it does not it indicates that lubrication is at fault or that it is not properly adjusted.

249. A good engineer will not rest easy until he has located and removed the cause of a hot-running crank box.

250. **Fuel Consumption** of an engine is always a legitimate question, and one of grave importance to the purchaser, as well as to the manufacturer.

251. Ordinarily about one and two-tenths pints (1 2-10) of gasoline or about fifteen feet of natural gas, per horse power per hour under full load, will cover the fuel consumption. That is, when the gases named are of standard quality and the water comes from the water jacket at a temperature of about 160 degrees Fahrenheit.

252. The temperature of the water in the chamber around the cylinder has very much to do with fuel consumption.

253. If water from a hydrant is forced around the cylinder so as to keep it cold, the heat from the explosions or combustion is cooled down so quickly by radiation that the expansive force is

materially reduced, and consequently less power from the same charge.

254. The object of the water is not to keep the cylinder Cold, but simply Cool enough so as to prevent the lubricating oil from burning. The hotter the cylinder with effective lubrication the more power the engine will develop.

255. It should also be remembered that an engine is the most economical in fuel consumption when working practically under a full load.

256. It is wrong to suppose that an engine taking fifteen feet of gas per horse power under full load should take only seven and a half (7½) feet under half load. When running empty an engine may use from thirty to thirty-five per cent. of its total fuel consumption under full load.

257. Speed has considerable influence over fuel consumption, especially in driving the engine empty. Take, for instance, an engine of four-horse power, run it empty at a speed of, say, 250 revolutions per minute and notice its fuel requirements at that speed, then increase the speed to 500 revolutions per minute and you practically double the fuel consumption running the engine alone.

258. It is not always practical for a manufacturer to guarantee fuel consumption. I should say it is seldom, if ever,

practical to do so without exacting from the purchaser conditions and requirements that would make him feel that the engine itself is not practical. In general the average fuel consumption may easily be kept down to the quantity above mentioned, although many conditions may arise to change the amount required.

259. It is not always the fault of the manufacturer if the fuel consumption overruns the estimate. It is more often the fault of the engineer in my opinion.

I should advise for economical fuel consumption:

First—To keep jacket water at 160 degrees Fahrenheit.

Second—To run engine at a medium speed.

Third—To use a good standard fuel.

Fourth—To see that every charge the engine takes is exploded, for which a proper mixture and a good spark or hot tube are necessary.

Fifth—The admission valve should close properly between charges, so as not to allow a continuous flow of fuel into the engine.

Sixth—Never throttle the fuel so closely that the engine can not get a full charge every time it needs it.

Seventh—Be sure that there is no leak in the supply or overflow pipes where fuel can escape.

Eighth—When gasoline is used be sure that there is no leak in the supply tank.

Ninth — Exhaust and Receiving Valves must set properly and not leak. Cylinder rings must hold the explosive force.

With these precautions one will use only so much as will be required by the engine to handle its load.

CHAPTER IV

GASOLINE ENGINE TROUBLES

260. Following are the five gas engine troubles that are most frequently met with: Defective Ignition, Pounding in the Cylinder, Loss of Power, Back Firing and Obstinate Starting, although the last is very often intimately associated with the first.

261. **Defective Ignition.**—The symptoms and causes for defective ignition are: Difficult starting, thumping in the cylinder and an occasional terrific report at the end of the exhaust pipe, Miss-firing, Premature Firing. It must not be taken for granted, however, that difficult starting is always due to defective ignition. But when an engine refuses to start after turning the wheels several times defective ignition may be suspected, and the igniting apparatus be looked after.

262. **Remedies for Defective Ignition.**—If a tube ignitor is used and the charge is fired too early, throwing the wheels backward, the flame should be raised so as to heat the tube at a higher point.

If the charge isn't fired at all, then the flame may be directed at a lower point on the tube. But in either event it is always best to have the tube quite hot (bright red hot) when starting. It can be cooled to a cherry red after the engine is running and yet fire its charges successfully. The port or passage between cylinder and tube must always be freed and unobstructed. It sometimes clogs with burnt carbon. Sometimes the builder makes this port too small. Clean if it is obstructed. Enlarge it if necessary.

263. When the battery is used for ignition purposes the timing of the spark is always important. The terminals should separate just before the crank passes the inner center. The switch may be disconnected. Some of the wires may be loose on their binding posts. The terminals or the movable terminal shaft may be gummed up or corroded and needs cleaning. The battery may be nearly exhausted and needs renewing. The current may be short circuited somewhere before reaching the engine.

264. **Short Circuit.**—If the zinc plates or any one of them should be allowed to touch the carbon within the cell it will cause an internal short circuit. If one wire from the battery to the engine should have its insulation broken at a point where it touches some pipe or

iron that in any way communicates with the other wire, there is an external short circuit. Broken insulation may short circuit the spark coil.

265. The Battery current is tested by disconnecting the end of one of the terminal wires and touching with it the binding post to which the other wire is attached. If it does not make a bright spark each time the wire is snapped or slipped off the binding post you can be sure that some of the causes above named are to be found, and as soon as the cause is removed the spark will show up all right.

266. If there is a good spark on the ends of the wires and a weak one or none at all at the point of contact of the terminals it indicates that the trouble is in the sparking mechanism on the engine. This mechanism is either corroded, gummy or short circuited. It should be thoroughly cleaned and closely examined for a short circuit. Carbon deposit coating over the insulation on inside of exploding chamber may cause a short circuit.

267. The **Sparker Insulation** can easily be tested by disconnecting the wire **Not** attached to the insulated terminal and snapping it off some of the bright parts of the engine, when the terminals are apart (the other wire being, of course, attached to the binding post on the insulated terminal), and if a spark is

made it indicates that the insulation is broken and consequently a short circuit. If no spark is made the insulation is all right.

268. There should be nothing loose or no lost motion about the terminals or the mechanism operating them.

269. Either a good fluid or dry cell battery will furnish a good spark from two to six months, according to the amount of work done with the engine. If the engine is used continuously for ten hours each day the battery may need renewing any time after two or three months.

270. I have on several different occasions found engines that absolutely refused to start when the battery and all connections seemed to be in good condition, but went off and ran perfectly from the first turn of the wheel after a new spark coil was placed in the circuit. The short circuit in the old coil was so deep down among the coils of wire that it could not be detected.

271. The character or appearance of the spark, and especially if of a scattering nature, should lead you to suspect a short circuited coil. An **Effective** or **Good** igniting spark is a **Single Blue-White Spark** at the point of contact. But beware of a dozen little sparks flying out in all directions from the terminals. They will ignite.

272. A battery may not be entirely ex-

hausted when it fails to give an igniting spark. The fluid in the cell may have evaporated so that the carbon element is not sufficiently submerged. I have repeatedly revived fluid batteries that were apparently exhausted by simply filling into each cell pure rain water to within one-half inch of the lid of the cell.

273. An old battery that has not been used for a long time, and in which the elements seem good, may be treated this way, and afterwards short circuited for about three or five minutes.

274. In fact in renewing a battery or setting up a new one it is always good policy to short circuit it for from three to five minutes by bringing the ends of the terminal wires in contact with each other. This creates a healthy chemical action within the cells, which is necessary to generate the electric current.

275. The current from a dynamo ignitor is tested, while the dynamo is running at its rated speed, by taking a piece of wire about two feet long with the insulation stripped off both ends, and placing one end onto one of the binding posts of the machine and snapping the other end off the other binding post. This will produce a faint spark if a current is generating, and by placing a spark coil in the circuit—that is, by taking two short wires as above de-

scribed and connecting one end of each to a binding post on the coil and using the other ends to make and break the current on the dynamo binding posts, you get the full benefit of the current and can judge of the igniting qualities by the size and color of the spark.

276. The fields of a dynamo should not become overheated, but should remain cool. The bearings should be oiled properly, and the brushes and commutator should have regular attention. It should be kept absolutely clean. For further information see chapter on Generator Ignition.

277. Before leaving the subject of ignition I wish to emphasize the fact **That a Gas Engine Is Not Running Properly** if every charge admitted by the governor is **Not Fired** or ignited. No one should allow his engine to run taking two, three or four charges in succession and only firing one of them, without immediately locating and removing the cause.

278. I recall a case of miss-firing and an occasional terrific report at the end of the exhaust pipe which was caused by the taper pin, which held the rocker arm to the movable stem, wearing loose and allowing lost motion at this point, which should have been rigid. A new and larger sized pin made out of a wire nail driven firmly into position completely overcame the trouble.

279. The lost motion made such an indefinite and uneven contact that only an occasional charge was ignited, which in turn ignited those previously forced through the cylinder, without ignition, into the exhaust drum and pipe, and the result was a terrific report at the end of the exhaust pipe, similar to the firing of a cannon. Every engineer should familiarize himself quickly with the natural sounds of his engine, and his ear will always be on the alert and detect any unnatural sound the instant it occurs.

280. I have been able correctly to say, "That engine is not firing all its charges," by listening to the exhaust reports half a mile across the country. The character of the sound of the exhaust reports, as well as their number between intermissions, will also tell you at a distance whether the engine has a light or a heavy load and whether it is overloaded.

281. The sense of hearing suspects and decides whether there is trouble when the engine is running. The sense of sight locates and corrects it. The sense of smell will tell you whether fumes of burnt gas are passing the piston rings or leaky valves, and escaping into the engine-room instead of outside through the exhaust pipe. The sense of touch tells you whether the journal boxes and other bearings are running cool. The

sense of taste is about the only one of the five senses that we do not need to detect some trouble about an engine. In fact I have seen engines running so badly that I imagined I could taste it. The ear, however, may be considered the chief guide while the engine is in motion.

282. **Pound in Cylinder.**—The principal cause of pounding in the cylinder is pre-ignition of the charge. Pre-ignition, as has already been stated, is usually caused by some projecting point or carbon deposit in the igniting chamber, heated to the igniting point. A high compression of the charge may also contribute to pre-ignition.

283. Of course a knock or pound at the wrist or crosshead, due to lost motion at these points, must not be confounded with a pound in the cylinder. A loose flywheel may also puzzle one at times, inasmuch as the jar or thump caused by it may sound like a thump in the cylinder.

284. I would test pre-ignition by throwing off the igniting current or shutting off the tube ignitor. If the engine continues to fire its own charges and runs along pounding away it is good evidence that the pound is due to pre-ignition. If, however, it ceases to fire the charges the instant the igniting current is cut off, pre-ignition caused by projecting points or carbon deposit

may be excluded. But the hot point on the tube and time of the spark must not be overlooked. If, however, the pounding keeps up until the engine stops, a tight piston is probably the cause of the trouble.

285. I have frequently shut off the current and gas from a pounding engine and noticed it stop dead sooner than you should expect it to. And when endeavoring to turn the flywheel over by hand the piston stuck tight in the cylinder. A few minutes' rest, allowing it to cool, will loosen up the piston.

286. If a piston is made to fit the cylinder too snugly it will usually result in pounding in the cylinder when the engine is put under a heavy load. The cylinder thump or pound is a deep, heavy pound, while a loose flywheel or loose wrist bearing is indicated by a thump more of the clicking variety. Then there is a **Barking Noise,** due to the escape of the **Explosive Force Past the Cylinder Rings.** This is easily distinguished from either of the others.

287. The object is to locate the cause of thump or pound wherever it is and remove it. Any one who is able to find the cause of the trouble will no doubt find a remedy that will soon correct the difficulty.

288. If pre-ignition is the cause the pounding will cease as soon as the combustion chamber is cleared of the carbon

deposit, the projecting point causing the firing is removed, the time of the spark set later or the flame on the tube elevated.

289. If the cylinder rings allow the explosion to pass, making a barking noise, they should be either replaced by new ones well fitted into their grooves and also to the cylinder, or the old ones should be dressed with a fine file, on their surface, so as to bear at all points of their circumference on the cylinder wall.

290. If the knock is in the crosshead it may be relieved by tightening up the bearing. Care must be exercised lest you get it too tight, which will make it knock more than ever.

291. If the knock is in the wrist, it is best to take it up little at a time. A loose flywheel must never be allowed to run until it is thoroughly keyed to the shaft and perfectly tightened.

292. I might add that pre-ignition is liable to cause undue expansion of the piston and cause it to stick in the cylinder. In such instances it is not proper to dress the piston until pre-ignition is corrected. A piston that sticks when pre-ignition occurs may run all right when pre-ignition ceases. The cause of this undue expansion of the piston from pre-ignition is the extreme heat the piston encounters while firing the charge

before the end of the compression stroke.

293. Don't conclude that a **Thump, Pound** or **Thud** about an engine is always due to some trouble in the cylinder. Look for such causes as the following:

First—Pre-ignition (premature firing).

Second—Badly worn or broken piston rings.

Third—The explosive force escaping by the piston.

Fourth—Improper seating of a valve.

Fifth—A badly worn piston.

Sixth—Piston striking some projecting point or foreign body in the combustion chamber.

Seventh—A loose crosshead bearing.

Eighth—A loose crank or wrist bearing.

Ninth—A loose nut or journal box cap.

Tenth—A flywheel or pulley loose on the shaft.

Eleventh—A broken spoke, hub or rim in flywheel or pulley.

Twelfth—Lost motion in any bearing, gear or governor.

294. The sound produced by pre-ignition may be described as a **Deep, Heavy Pound.**

295. A loose flywheel causes a thump, or sometimes a sort of metallic grating sound.

296. A loose crosshead or crank bearing makes a thud or knock.

297. A click will usually direct attention to a loose nut or cracked rim, spoke or hub, on pulley or flywheel.

298. **Loss of Power.**—Loss of power is due principally to choked inlet or exhaust passage miss-firing, loss of compression, etc., in four cycle engines possibly to leaky valves. A bent exhaust lever or lost motion by reason of a worn condition of the cam and cam roller, which will prevent a full and free opening of the valve will cause a constricted passage.

299. Under leaky valves may be considered leaky piston rings, or any point about the cylinder where part of the explosive force escapes while it is driving the piston on its working stroke.

300. The valves, if leaking, should be taken out and thoroughly cleaned and ground into their seats with powdered emery and lubricating oil.

301. If the cylinder rings are so worn as to become leaky or allow escape of the explosive force, they must be replaced by new ones, and it is sometimes necessary to put the piston into a lathe and true up the grooves to fit the new rings. If any point of leak is discovered it should be properly packed or plugged at once.

302. **Miss-firing** means failing to fire each charge the engine takes, and the remedy

has already been given. It consists of examining the battery and all its connections to the terminals, and determining whether the battery is exhausted or not, whether there are broken connections, whether the terminals or other points need cleaning or attention otherwise. If tube ignition is used, whether the tube is hot enough, whether it is heated too high up, whether by corrosion or other means the passage from the cylinder to the inside of the tube is closed up. Also determine whether fuel is fed to the engine in proper quantities. May not be getting enough at a charge or even too much.

303. **Choked Inlet Passage.**—Nearly all gas engines are fitted with some kind of a mixing device in the shape of a perforated plate, wire screen, etc. These mixing devices may become occluded with dust, soot, waste, cloth or paper drawn into the inlet pipe. The strangest of all is that they sometimes become occluded with ice. The rapid vaporization of the gasoline while passing through the mixer may freeze any water elements in the air and gasoline, and deposit it in the shape of ice in the mixer until it becomes completely occluded.

304. The engine may start off and pull its load easily and as the ice is gradually deposited in the mixer the engine shows

less and less power, until it finally stops. A wait of five or ten minutes will melt the ice sufficiently to allow another short run. Such actions or symptoms should lead one to suspect a frozen up mixer and to look for the cause.

305. In a number of such instances that came under my notice I have simply removed the mixer screen entirely and ran the engine without it, which overcame the trouble entirely.

306. Whatever the cause of a choked inlet, see that the cause is removed.

307. **Back-Firing.**—The explosive force coming out of the mouth of the receiving pipe is called Back-firing. Its principal cause is a delayed combustion of the previous charge. When the air entering the cylinder does not receive a sufficient charge of gas or gasoline it makes a slow burning mixture. This mixture may be so slow in combustion that it continues to burn not only on the working stroke, but also on the exhaust stroke of the piston, and there still remains enough flame in the cylinder to fire the fresh incoming charge, which of course escapes back through the receiving pipe, the receiving valve being open.

308. Any projecting point of iron in the igniting chamber or chunks of carbon deposited in the cylinder may become heated to a red heat and serve to ignite the incoming charges.

309. Feeding the fuel a little more freely will remedy the back-firing if caused by a weak mixture. If this does not control it, chunks of carbon or projecting points of iron or carbon should be looked for and removed if found.

310. **Obstinate Starting.**—Defective ignition is one of the principal causes, and you have already been told the remedy. But **Slow Vaporization** of gasoline in cold weather, **Overcharging the Ingoing Air** with gas or gasoline when turning an engine over by hand, and **Water in the Cylinder** when trying to start, are causes as frequently met with as Defective Ignition.

311. You can facilitate vaporization of gasoline in cold weather for starting purposes by previously heating some point of the air inlet pipe, which serves to warm the air as it enters, which in turn vaporizes the gasoline better than cold air.

312. A bottle of gasoline heated by holding it in hot water may be used for starting. The heated gasoline vaporizes easier.

313. To avoid overcharging the ingoing air when turning the wheels over slowly in starting, a starting cup may be used on mouth of receiving pipe instead of turning on gasoline by the needle valve. This gives the initial impulses. After a few impulses are received, by opening the needle valve very slightly and grad-

ually increasing the opening the proper starting point is found. The valve set at that point will usually start the engine when the wheels are rolled over.

314. If **Water** is found in the cylinder it must be removed and the leak stopped before a start is made. Sometimes a leak is so slight that it will not affect the running of the engine after it is started, but will leak enough while the engine is idle to prevent starting.

315. Therefore it is always well to drain the water jacket entire before stopping the engine, and to start the engine before turning the water on again. Forming a habit of thus draining the water off before stopping the engine will serve an excellent purpose both in a leaky cylinder and in cold weather.

316. **Ground Joints** that become leaky should be reground with flour of emery and oil, and wiped perfectly clean after sufficiently ground.

317. **Leaky Valve Stems** are remedied by reaming out the bearing and putting in a bushing or a larger stem. The stem, of course, must be in line with the bearing centers of the valve seat.

318. **If Ignition Gradually Fails,** make the tube hotter. Renew battery or have magneto or generator put in order by an electrician.

319. **Weak Explosions,** when engine is starting, hardly strong enough to drive

engine up to speed, indicate leaky valves.

320. **If Speed Gets Lower and Engine Finally Stops,** suspect:

First—Irregular ignition; charges not all fired.

Second—Overheated cylinder or piston.

Third—Hot journal or wrist box.

Fourth—Overload on engine.

Fifth—Fuel supply exhausted.

Sixth—Exhaust or receiving valve leaking.

Remedies—

First—Repair broken wire connections, clean electrodes or igniting mechanism, repair insulation, renew battery, attend to magneto or sparking dynamo. Heat igniting tube to a higher degree.

Second—Increase supply of cold water and lubricating oil.

Third—Stop engine, examine hot box; if cut any, dress all rough places, and wipe out all filings or cuttings, readjust boxes to bearings carefully, lubricate well, start engine, and keep a close watch on it for several days. If it shows any tendency to heat, examine again and readjust.

Fourth—Reduce load on engine.

Fifth—Replenish fuel supply.

Sixth—Grind the valve that leaks to a good seat with emery flour and oil.

Leaky valves and piston rings can be tested by turning the engine wheels over till the piston goes on its compression stroke. If the valves and piston hold, the compression of air causes the piston to rebound. If they leak, you can turn the wheel on over the compression stroke.

321. **Smoke** at the end of the exhaust pipe means an over supply of fuel or a surplus of lubricating oil in the cylinder.

322. Set needle valve closer so as to feed less gasoline or gas. If this does not stop the smoke, feed less lubricating oil into the cylinder.

323. **Smoke** at open end of cylinder indicates that there is either a sand hole in the piston, leaky rings, or that the lubricating oil in the cylinder is decomposed by the heat.

324. Piston taken out and filled full of water will test it for a sand hole or other leak.

325. When piston is out examine rings if broken or worn out, or show by wearing at only one or two places in their circumference that they do not fit the cylinder, replace them with new ones snugly fitted into the piston grooves, as well as turned to fit the cylinder. If lubricating oil is burning increase supply of cold water.

CHAPTER V

GENERAL INFORMATION

326. **Bound Boxes.**—When either the crosshead or wrist boxes become worn so that they shoulder tightly after all the liners are taken out, without correcting the lost motion or knock, their shoulders must be dressed either in a shaper by a machinist or filed true so that they can be set snugly to the pin they inclose and yet do not shoulder by from one-eighth to one-thirty-second of an inch.

327. **Liners.**—The space between bearings is sometimes filled in with a number of thin sheets of cardboard or brass called Liners or Shims.

328. **Liners Removed.**—As the boxes wear one liner at a time is removed and the nuts on the boxes set up a little closer.

329. **Setting a Box.**—Never set a box so close as to bind the pin or shaft it encloses. But set it close enough to prevent it knocking. Set the nuts, holding the box, up equally. Bring them up gradually together. Never set one up tight before bringing the other up.

Don't be in a hurry. Don't set the boxes haphazard. Try the box after setting by turning the wheels over to see if it works tight and stiff. If so, it is too tight. Use judgment, otherwise you will have a ruined box.

330. **Pins Worn Out of True** should be calipered and dressed round again with a file, or, better, put into a lathe and trued up with a tool and file. This refers principally to the **Crosshead** or **Piston Pin,** and the **Crank** or **Wrist Pin.**

331. **Cut Boxes.**—Scrape the box or file it smooth with a fine file. Do the same with the pin by dressing off all the ridges and grooves.

332. **Hot Boxes.**—Watch all the bearings on your engine closely, especially while new. If any of them run hot stop your engine and examine carefully for the cause. If too tight loosen it up a little; if it bears heavy on one side dress the point carefully where it shows the most wear; if a burr or high point on the shaft or pin dress it down smooth, but don't let the box run hot very long at a time.

333. **Re-Babbitting a Box.**—If you have never seen a box rebabbitted you had better not undertake it until you have called in some one who has had experience to assist you. But if your judgment is good and you have sufficient confidence in your ability to do a thing

properly you can do it alone. The principal things to be observed: Get the box perfectly level, clean out all the old babbit, have the box perfectly dry, adjust shaft in perfect line with the cylinder and the other box or bearing and stay it thoroughly so it will not be jarred out of place while babbitting. Cut cardboard to fit around the shaft and the ends of the box, and then paste the cardboard to the ends of the box by means of putty or clay, and then close up all the creases with it where babbit might run out. When all is ready to receive the metal, which should be hot enough to quickly char a small stick thrust into it, put a piece of rosin onto the metal and pour as steadily as possible into the box. Babbit only half of the box at a time.

334. **Packing.**—The cylinder head and valve chambers are in many engines packed onto the cylinder. Probably the best "all-round" packing to use, and the most easily procured, is Asbestos sheeting or board. Some builders use a packing called **Rubber Bestos.** Asbestos will stand the heat better than any other packing known.

335. **Lime Deposit in Water Chamber.**—Don't let water chamber become filled with lime deposit. Better clean it once a month by taking off Cylinder Head and scraping the jacket free from lime.

336. If you are called on to clean a jacket

that is well filled with lime and difficult to remove by scraping, the Hot Oil process of removing the lime is, we think, the least injurious.

337. It is done as follows: Drain all the water from the jacket, plug the lower port into the jacket, and through a short nipple of pipe in the upper port fill the water space with oil. Then run the engine till the oil gets boiling hot. Then let it stand over night to cool. Heat it again to the boiling point next morning by running the engine. Then stop the engine, drain off the oil and let the engine cool off. Then start your engine with water turned on, and run for several hours, and when cooled shut off the water and thoroughly drain off all sediment.

338. **A Burst Water Jacket, the Result of Freezing.**—No matter how much is said or written in the way of caution about draining the cylinder jacket and water pipes, carelessness will prevail in some instances and a freeze up, bursting the cylinder jacket, will occur.

339. It is fortunate, however, that the cylinder itself is seldom injured by these freeze-ups. Usually only the outer casing bursts, and hence does not interfere with the successful running of the engine.

340. When the exhaust valve chamber is watered the same trouble will occur with it if it is not properly drained.

341. When a freeze-up occurs it results usually only in cracking the water casing and the remedy is to patch it and go ahead.

342. The patching is done as follows: Drain off all water, plug lower pipe connections, fill jacket with a salammoniac solution (one pound to a gallon of water), let stand thirty minutes, drain and run engine five minutes to warm jacket. Stop engine, put solution back into jacket and repeat the process three or four times. If the crack is not too large you will thus form a **Rust Joint** that will never leak.

343. If this does not stop the leak, take an iron plate, long enough to cover the crack, shape it to the cylinder, drill quarter-inch holes along each edge about two inches apart, drill and thread holes into the cylinder wall to match, lay a piece of candle wick, well saturated with white lead, on the crack and bolt the plate tightly over it with one-quarter inch round head screws. When using this method it is best to chip a little crease along the crack to receive part of the wick.

344. **How to Grind a Valve.**—As has already been stated, nearly all modern gas engines use valves of the poppet variety. When it is suspected that a valve needs grinding, strip the stem of its lock-nuts and spring, and remove the cap or plug over the valve pallet, lift it out and examine the seat.

345. If it does not show a good bright bearing all around it needs grinding, which is done as follows: Apply lubricating oil to the seat of the pallet, then sprinkle on some flour of emery and drop the pallet into its seat. The top of the valve is usually creased to receive a screwdriver bit.

346. With a brace and bit the pallet may be turned round and round for a time and then back and forth in a semi-circle. Work it this way, alternating the movements, for some time. Occasionally lift the valve pallet slightly from its seat, let it drop back and repeat the grinding movements.

347. When the valve turns without any apparent grinding friction take it out, wipe it clean, examine the seat, apply more oil and emery, and put it through another course of grinding.

348. This process may have to be repeated a number of times, but don't get in too much of a hurry to get through.

349. Two hours spent industriously on a valve may prove to be well spent and time saved.

350. When a good bearing seat is secured wipe the valve pallet and stem, as well as the valve seat and sleeve, in which the stem works, entirely free from emery, oil and grit. Return the pallet to its seat, close up the valve and adjust

the spring and lock-nuts to the stem ready for service.

351. In handling a gas engine the first thing to learn is "not to be afraid of it." There is nothing about it that will injure or hurt you unless you allow yourself to become careless.

352. Such incidents as getting arms, legs and clothes caught in the gears, shaft, governor or **Fly Wheel Key,** while the engine is running, are results of pure carelessness.

353. It is the engineer's duty to caution others who may be looking at his engine of these dangers.

354. **Exploring the Interior of the Cylinder.**—It is sometimes necessary to explore the interior of the gas engine cylinder with a lighted candle, for the purpose of locating some sharp projection, burnt carbon, crack or sand hole, etc. When doing this always remember that a **Charge of Fuel** may remain in the cylinder, and whether the candle is inserted through one of the valve ports or the open end of the cylinder, be sure to keep **Your Face** away from the opening.

355. The lighted candle will ignite the charge, and the flash through the open port may result in a seriously burnt face. The candle is usually put into the cylinder on the end of a long, sharp pointed wire or stick.

Horse Power Explained.

356. Every engine uses a certain per cent. of its total power to drive itself.

357. A. H. P.—**Actual Horse Power** means the power an engine has to spare for driving other machinery after driving itself.

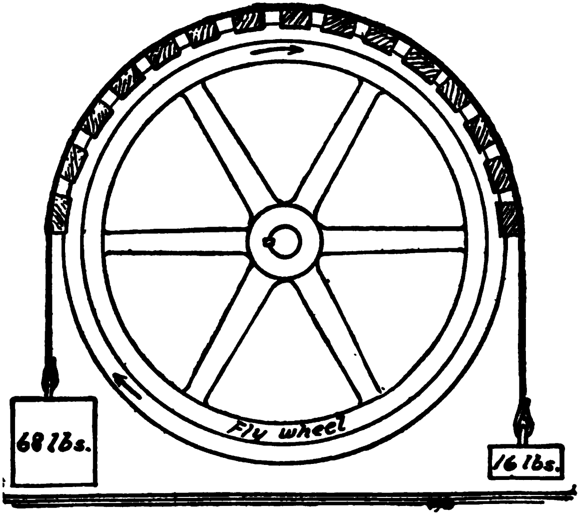
358. I. H. P.—**Indicated Horse Power** is A. H. P. plus the power an engine requires to drive itself.

359. **Total Power** of an engine is the same as its I. H. P. **Brake Horse Power,** B. H. P., same as A. H. P.

360. If an engine develops on Brake Test seven Brake Horse Power, or Actual Horse Power, and it takes 3 H. P. to drive itself, it is therefore properly called a **Ten Indicated** and **Seven Actual** or Brake Horse Power.

361. **Indicated Horse Power** is determined by an instrument called an **Indicator** attached to the compression chamber of the cylinder, which is capable of indicating the pressure behind the piston by tracings on a card. The power is figured from the area of this tracing, as follows:

Multiply the area of the piston in square inches by the mean effective pressure in pounds per square inch, and by the number of explosions per minute. Multiply the quotient thus obtained by one-half the piston speed in feet per minute (if a single-acting en-



Method of Making Brake Test.

gine) and divide by 33,000; the quotient will be the indicated horse power.

362. **Brake Test.**—A piece of belt with linwood cleats fastened to it with wood screws, as per the above illustration, will serve to make an excellent arrangement for testing brake or actual horse power.

363. On each end of this brake a paint bucket with bail or handle hung onto hooks fastened onto the ends will serve to hold small stones or chunks of iron

with which to weigh the brake and cause sufficient friction.

364. This weight is applied until the engine is pulling all it will pull without materially reducing the speed, and the weights on each side balance or hang clear of the floor.

365. The engine is then left running under its load for from ten to thirty minutes, during which time the speed is counted a number of times, to determine whether the engine holds the same speed.

366. When you have maintained the same speed for some time the test may be concluded by stopping the engine.

367. The weights on each end are then weighed and the difference in pounds is the number of pounds pulled by the engine.

368. By multiplying the **Circumference of the Wheel in Feet** by the number of pounds pulled by the number of revolutions per minute, and dividing this product by 33,000, the result will show the Actual or Brake Horse Power of the engine.

369. **Example.**—Diameter fly wheel shown in above cut thirty inches, or two and a half feet. 2½x3.1416 equals Cir. 7.85 feet.

$$\frac{\overset{\textbf{Cir.}}{7.85 \text{ ft.}} \times \overset{\textbf{Rev.}}{300} \times \overset{\textbf{Pounds.}}{52}}{33000} = 3\tfrac{7}{10} \text{ h. p.}$$

370. A power capable of raising 33,000 pounds one foot high, in one minute, equals one horse power.

To Start a Gas Engine.

371. Don't get excited. Go slow. Be sure you are right, then proceed as follows:

First—Clean the engine and all wearing parts thoroughly.

Second—Oil every point where there is any friction, **Except Valve Stems and Sparker Shaft.**

Third—If there is a relief or starting lever on the engine set it so as to relieve the compression. A Pet-Cock is sometimes used for this purpose instead of a lever. It should be open.

Fourth—Switch in Battery current. If tube ignitor is used the flame against the tube should be started first thing. While the tube is heating oil up, etc.

Fifth—When hot enough open the throttle valve slightly so as to admit a light charge of fuel when the engine is turned over. **Remember** you are more liable to give the engine too much fuel in starting than not enough.

Sixth—Turn the fly wheels of the engine rapidly forward till it gets an impulse. Three or four revolutions should be enough.

After the engine has had three or four impulses and gained some speed throw out relief lever or close relief Pet-Cock.

Eighth—Start oil from lubricating cup on cylinder. Twenty drops per minute while engine is new. Less will do later on.

Ninth—Let water into jacket chamber from water supply.

To Stop a Gas Engine.

372. First—Shut off water supply.

Second—**Drain Cylinder Always. Take No Chances of a Freeze-Up,** if you want to avoid trouble.

Third—Close cylinder oiler.

Fourth—Shut off gas or gasoline.

Fifth—Switch out the battery current.

Sixth—Wipe engine clean and see that it is in good shape for its next run.

373. While cleaning the engine after each day's run notice all the points of adjustment that are liable to need attention and see that all nuts, bolts and cap screws are tight or properly set.

374. Notice also the condition of the wrist, journal and other bearings. If any of them are hot, locate the cause of the heating, and, if possible, remove it before starting the engine for work.

375. Before leaving the engine for the night see to it that the gas or gasoline is shut off and properly confined in the tank or pipes, that the battery current is switched out, and that everything is in apple-pie order for the next run.

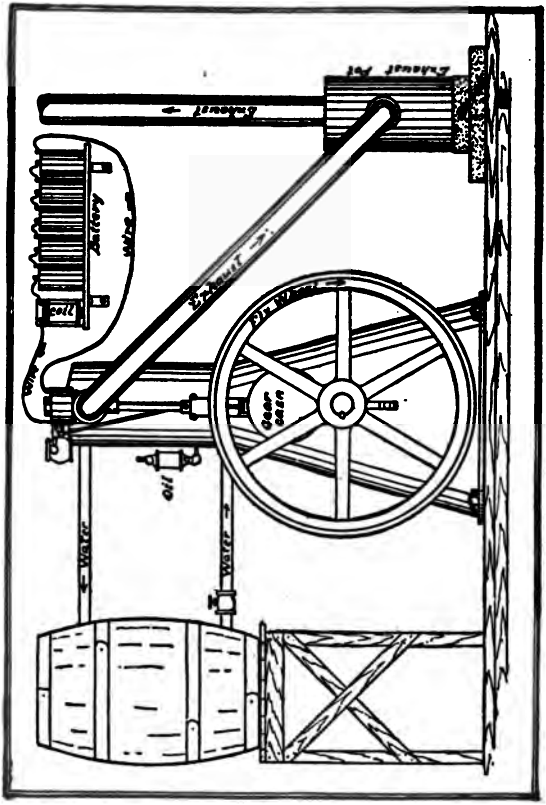
376. The illustration on the following page is intended, in a general way, to show the manner of connecting up the water, exhaust pipe and battery to the engine.

377. You will notice the bottom of the cooling tank is about on a level with the inlet to the engine. I think this is a very important point to remember. It is better to have as few obstructions as possible in the water connections, where a natural circulation is expected. Therefore the cooling tank should be so placed that the water through the lower pipe to the engine will flow at least on a level and not upward. There are no objections to placing the tank above the engine.

378. It is also well to observe that the lower pipe is connected a few inches above the bottom into the side of the tank, thus arranging a space below the pipe outlet to collect any sediment the water may contain, which would otherwise be carried into the cooling chamber of the cylinder, and tend to obstruct it.

379. The bottom of the cooling tank should be provided with a drain cock or plug, through which the tank may occasionally be drained of all sediment and thoroughly cleaned.

380. The cooling tank, exhaust drum and battery can of course be placed and connected to suit the location of the


Exhaust Pot
Exhaust →
Battery
Wire
Coil
Wire
Exhaust →
Fly Wheel →
Gear case
Oil
Water
Water →

engine. They do not need to occupy the positions in relation to the engine as shown in the cut.

381. Place them where they are most convenient, connecting up the water and exhaust with as few "L's" and turns as possible.

382. The pump and gravity feed systems for supplying gasoline to the engine have been fully described, as also the method of piping up the gas. See index.

383. **Gasoline, Benzine, Naphtha** and the kindred Hydro-carbons are products of crude mineral oil.

384. They are separated from the **Crude Oil** by a process of distillation. The process is very similar to that of generating steam from water.

385. By the application of heat, water raised to a temperature of 212 degrees Fahrenheit changes from a liquid to a gaseous state, called steam. This conversion is only temporary. If steam is confined and cooled to a certain point it will quicky return to its liquid state, water, by the process known as condensation.

386. **Crude Mineral Oil** subjected to heat will give off in the form of vapor such products as Gasoline, Benzine, Naphtha, etc. The degrees of heat at which these products are separated are comparatively low. Various degrees of heat will separate the distinct products.

As a means of illustration, we will say that crude oil raised to a temperature of 110 degrees gives off vapor which when cooled will liquefy into what is known as naphtha; benzine at 125 degrees, and gasoline at 140 degrees. These degrees of temperature are not authentic—simply used to illustrate.

387. After these lighter products are separated there yet remains the thick, oily liquid from which the various lubricating oils are prepared.

388. Paraffine oil is one of the principal products of crude oil, and the oily sediment which frequently accumulates in the bottom of the tank or can in which gasoline is confined is **Paraffine Oil,** which distills over in small quantity with the vapor of gasoline.

389. This oil might be finally separated from the gasoline by reconverting it into vapor several times and carrying it as such into a clean retort each time.

390. It should be remembered that gasoline that is practically free from paraffine can easily be adulterated by putting it into unclean containers. For instance, we take chemically pure gasoline and put it into a wooden barrel or tank, that previously contained oil, which has not been cleaned, it is easy to understand how the penetrating qualities of gasoline acting on the oil-soaked staves will extract the oil particles and deposit them on the bottom

of the vessel because of their lower specific gravity. In the same way other sediments than oil may get mixed with gasoline.

391. The comparatively low degree of heat necessary to produce gasoline from oil makes it a fluid that is very volatile and easily vaporized in our warm summer temperature, and, therefore, difficult to confine.

392. The best kind of a tank to use in confining gasoline is made of well soldered, galvanized iron, fitted with a safety valve, which will allow escape of any gas that may accumulate to a certain pressure within the tank during warm weather.

393. A tank containing gasoline should never be so placed as to be exposed to the direct rays of the sun. This is done with many gasoline engine supply tanks and the result is an enormous waste of gasoline by direct vaporization, which loss is generally attributed to over-consumption by the engine, very much to the detriment of its reputation.

394. The object of burying a gasoline tank in the ground is to provide a cool place for it, which reduces vaporization to a minimum. The way this is ordinarily done is **Bad Practice.** The proper way to do it is to provide an underground chamber something similar to a cistern. This chamber should be large enough so that when the tank is placed in the

center there is room enough all around it to admit of thorough inspection. It should be walled up with brick and cemented so as to exclude water, and covered in such a manner as to admit of easy access.

395. If the tank is to be placed on top of the ground outside of the building in which the engine is located it should be protected from the heat of the sun by putting a small building over it.

396. Storing gasoline in a wooden barrel is not economy by any means. The wood is porous enough to allow considerable loss by vaporization.

397. When gasoline is exposed to air that is above the freezing point it gives off a vapor or gas which mixes or blends with the atmosphere, and if exposed long enough the quantity so exposed will all disappear or pass off into the air in the form of vapor, leaving only the paraffine residue or other sediment.

398. Several manufacturers of gasoline advise me that common stove gasoline is especially purified, and does not originally contain any residue.

399. It would therefore appear that stove gasoline, which is ordinarily supposed to test about 74 degrees, is the quality best adapted for use in the gasoline engine, although the writer has knowledge of engines running successfully on gasoline testing anywhere from 60 degrees to 88 degrees.

400. **Distillate,** which might be called a low grade of gasoline, and which we are advised tests about 55 degrees, is successfully used to operate the majority of gas engines in California.

401. Much of the **Residue** or oily substance which accumulates in the bottom of a gasoline tank is, in my opinion, due to the use of unclean barrels or tanks in which it is confined for storage or shipping purposes.

402. Another method of getting rid of this oily substance is to regard it as so much "dirt" and occasionally pour off all the gasoline and clean the container thoroughly from all sediment.

403. Gasoline engines often refuse to operate successfully on account of this sediment blockading some part of the supply passage between the tank and the engine.

404. Unfortunately the consumer of gasoline occupies the same position in the purchase of gasoline as the consumer of milk does in its purchase. They both buy "dirt." The only difference is that the latter, after buying it, is expected to digest it as well.

405. In case of fire due to gasoline, use fine earth, flour or sand on top of the burning liquid. Never use water; it will only serve to float the gasoline and consequently spread the flame.

406. **Gasoline Tank Explosions** are often due to the pressure within a tightly

closed container, caused by high temperature, which vaporizes or gasifies the liquid within.

407. The changing of the liquid to the gaseous state causes expansion, and if there is no vent or safety valve connection the pressure within rises to a point sufficient to cause an explosion.

CHAPTER VI

DYNAMO AND MAGNETIC IGNITION IN GAS AND GASOLINE ENGINES

408. The necessity of a sure method of ignition in the operation of gas engines cannot be overestimated. Undoubtedly more trouble arises from defective ignition than from all other causes combined. The importance therefore of some arrangement, device or mechanism, capable of constantly generating a good strong current of electricity, with the least possible variation in its strength is readily apparent.

409. Experts on the operation of gas and gasoline motors are very particular about the igniting apparatus on their machines. When called to a motor giving trouble they will at once inquire or examine into the ignition apparatus, and especially the electric current strength. If this current strength drops below a certain standard, say 2½ amperes and 10 volts, the expert suspicions that the current strength is getting low, and he searches for the cause.

A high amperage and low voltage may ignite successfully. Such a current may be had from a battery on short circuit. A five-cell Edison Primary Battery, Type "R," may show on short circuit 15 amperes and only three to four volts.

410. **Magneto Ignition**—This form of ignition is very popular at present. It is used on practically all automobile and aeroplane engines, on the better class of marine engines and to a considerable extent on stationary engines.

411. Although more expensive than batteries, it is much more positive and reliable, produces a "fatter" spark and consequently is more efficient. A magneto will also outwear any number of batteries.

412. There are two types of magnetos—low tension and high tension.

413. **Low Tension Magneto**—This produces an alternating current and may be used with either make and break or jump spark ignition, although a slightly different construction is needed in each case.

414. Friction, belt and gear driven installations are employed, the belt drive offering the advantage of not slipping if fly wheel becomes wet.

415. When magneto is properly installed, engine can generally be started on magneto, no batteries being necessary.

416. In high tension magnetos there is

both a low tension and high tension winding, so that when the circuit breaker breaks the circuit on the low tension winding, a jump spark or high tension current is induced in the high tension winding which jumps the gap in the spark plug and consequently ignites the mixture.

417. No spark coil, timer, or batteries are necessary with high tension magneto.

418. With an efficient high tension magneto, batteries are not necessary to start with, provided engine is not too large to be cranked over compression at the rate of about 40 to 50 R. P. M.

419. **Dynamo**—The dynamo is generally used for heavier work than the magneto. It is very similar to the magneto in principle, the difference, briefly, being that in the magneto the field magnet is permanently magnetized, while in the dynamo a certain amount of the current is taken from the system and utilized to magnetize the field.

420. The ignition of a gas engine is the most difficult part about it to learn or master. Reliability, economy, safety, attention, convenience, and cleanliness are the principal points to be considered.

421. It is the opinion of the author that a machine, whether dynamo or magneto, will give the best service, and last longer at a uniform rate of speed, than under a variable speed.

422. It is, of course, the desire of all manufacturers to develop and produce a machine that will as readily as possible adapt itself to the various adverse conditions which it may encounter, and since variation in speed is an adverse condition constantly met with, they have given the matter of speed special attention, by reason of which some of them may be led to make extravagant claims for their product.

423. Conservativeness in the consideration of the excellent points claimed by each manufacturer is the safest guide to the purchaser. To make a good selection one should carefully consider the advantageous points claimed by different manufacturers, as well as the disadvantages urged against each other.

When you have made your choice, back up your judgment with the belief that you have as good a machine as the market affords, give it such attention as a good machine deserves; study its parts and their action until you are intimately acquainted with its makeup, and your success with it is assured.

424. There is yet another generator, which has recently made its appearance on the market. On account of special advantages claimed for it, which advantages are backed up by the action of the machine in several instances coming under my observation, I am inclined to regard it with considerable favor, and believe

it is destined to become a formidable rival of the other two, if not a leader. In describing the construction of this machine I do so with the understanding that the manufacture of it is not confined to one concern.

This generator might aptly be termed a Magneto-Dynamo, or a combination of dynamo and magneto.

425. The construction of it is similar to a magneto, with the exception that its permanent magnets are re-enforced by field windings similar to the dynamo.

426. As indicated in the description of the dynamo and magneto, the former depends on its field windings for exciting its fields from which its current is generated; the latter depends on permanent magnets for the generating of its current. The rapidly revolving armature between the wound fields of the former excites them, and a current is generated. The armature revolving rapidly between permanent magnets in the latter generates a current.

427. A current of electricity passed through a wire coiled around a piece of soft steel magnetizes the steel. Consequently, the field windings, around the already magnetized magneto, or permanent magneto tend to intensify their magnetism, and keep their generating qualities up to a high standard. It must, therefore, follow that such an arrangement would obviate the loss of

magnetism in the permanent magnet, an objection urged against the ordinary magneto.

428. However, it might be well to state in this connection that if this machine is run backward it will demagnetize its magnets. Therefore, the reader may at once conclude that there is an objection to this Magneto-Dynamo. If further consideration is given the matter it will be seen that there is no need of running this machine backward. In fact, by changing two wire connections between the field coil and the armature pole the backward movement above referred to becomes the forward. Therefore, the machine is easily reversible, and will run in either direction and generate a good strong current.

429. All that is required of the operator is to know the wire connections between armature and fields, which are usually plainly illustrated and described in an instruction sheet sent with the machine.

430. Another advantage claimed for these machines is that the magnet or field windings serve in the capacity of a spark coil, which obviates the necessity of a spark coil, and especially so if the generating speed can be made low enough to ignite the charge when turning the engine wheels over by hand, as in starting, and yet not injure the windings when the engine is at its full speed,

which we are informed is easily within the capacity of the generator.

431. Since referring to the spark coil we desire to say that it has been in use as a necessary fixture ever since electric ignition was introduced, no matter what the source of electric current, whether storage, dry, or fluid battery, Magneto or Dynamo. For the ordinary contact or touch spark a **Short, Thick** spark coil connected somewhere into the circuit will produce the best results.

432. For **Jump Spark** ignition an especially designed spark coil is necessary, called the Jump Spark Coil.

433. The difference in operation of the ordinary spark coil and the Jump Spark Coil is that the former requires a make-and-break arrangement, which produces contact and separation of the terminal points within the igniting chamber.

The latter produces a spark or succession of sparks, which leap through an air space between two terminal points, without contact of these points, which are stationary, and located within the exploding or igniting chamber; the make-and-break contact being made outside of the igniting chamber.

434. The same strength of electric current will produce successful ignition with either coil, provided the coils and ignition arrangement are adapted to the

current. In further explanation of this fact I might add that by a series of tests we produced successful ignition and operation of a gas engine by first using the ordinary spark coil with make-and-break contact within igniting chamber for several hours, then changing the igniting mechanism to the Jump Spark method we got equally good results, using the same battery and engine with both methods. Similar tests with a magneto current produced successful ignition with either method, demonstrating that a properly constructed battery or generator producing a current of sufficient magnitude will successfully ignite the charges with either the contact or jump spark method. However, jump spark ignition requires a current of greater amperage than is necessary with the touch spark, and which is liable to destroy the contact points. Hence builders of magnetos and sparking machines wind their machines a little different for a jump than a contact spark.

435. In the panorama of electric ignition, inventions, improvements and advancement, the changes are so rapid that one has hardly time to stop long enough to describe the newest arrival until another, for which greater claims are made, appears on the scene. While I write my attention is called to one which is termed a **High-Tension Gen-**

erator which is designed to produce a jump spark of powerful igniting qualities without the introduction of a spark coil in the circuit. It is claimed for this device that the current is taken from the dynamo terminals at a pressure of 25,000 volts, directly to the sparker plug, where it is delivered with such force as to enable it to bridge an air gap of an inch, with a powerful hot flaming spark.

The author has had no opportunity to personally investigate the action of this generator, and therefore is not able to judge or predict what role it is destined to play in these sparking times. It is safe to assume, however, that the inventor has gained some point of vantage. Whether of sufficient prominence to dictate its leadership remains to be seen.

436. Leaving the descriptions of what appear to the author to be the most reliable igniting generators now on the market we will attempt to devote a few pages to the care and successful handling of these little machines. I desire to say, as a word of caution, that it is not well to condemn a generator or magneto because the engine to which it is connected goes dead under its current or even its lack of current. The little generator may be all right, even if it produces no current at all. If the engine goes out of operation apparently

of its own accord be sure that you determine whether the trouble is with the generator or not. If a battery is used in connection with this generator, and the engine starts off and runs successfully from the battery, but goes down when the generator current is switched in, then it may be tolerably certain that the generator or the wire connections between it and the engine are at fault, not necessarily so, however. Some generators require a little time after starting to pick up or saturate their fields, before which a current is not generated. And if the engine is started on the battery, and switched onto the dynamo before it has had time to pick up, the engine will stop; therefore it is always well to run on the battery for a few minutes before switching in the current from the generator.

437. Under these conditions, should it fail, **Look for Little Things,** before giving up in despair. I'll relate an actual occurrence. It may help you. Mr. M— had worked all day up to 4 o'clock P. M., trying to get his engine started from his generator. (He had no battery.) At 4 P. M. we answered his call for help, and found him irritable, damning the dynamo and denouncing it as a fraud. Inside of two minutes we found one of the brushes—two at opposite points of the commutator, you know—by reason of dirt accumulation, got

stuck in the brush holder, and could not touch the commutator. Took it out, cleaned it, and also the other one, rubbed the commutator a little, turned the engine over, and off it went. Don't let this happen you.

438. Later on the same fellow literally soaked the dynamo in oil in his effort to give it sufficient lubrication. The result, of course, was another shutdown, fit of anger, and general condemnation of the spark generator. Cleaning and wiping off the surplus oil, again started it off in good shape. This fellow was constantly overlooking the little things, and believed as some one told him that his armature was burned out, or that the magnets had lost their magnetism.

439. Nearly all these little machines are fitted with wick oilers, and they need to be supplied with oil only every three or four days, and then only a little at a time.

440. The ends of the brushes which are in contact with the armature sometimes need to be touched up with a fine file to clean them from dirt accumulations. The commutator can be cleaned with fine emery cloth, waste or chamois skin, while it is in motion.

441. If the brushes wear off and get too short, so that the springs which hold them to the commutator can no longer hold them firmly, new ones should be put into the brush holders. We found

in one instance that the little pulley was loose on the armature shaft, which caused trouble for some time.

442. If you ever have occasion to remove the armature from a magneto, be sure that you protect the magnets by putting a small bar of iron across the open ends of the magnets. This makes the connection between the open ends of the magnets and preserves their magnetism, which they would otherwise lose.

443. It is also well to guard against running these little generators backward. Magnetism in some of them may be lost thereby, and they may be otherwise injured. If one of them has its field windings burnt out, or has lost its magnetism, it is best to send it to the manufacturers for repairs.

444. Sometimes the insulation around the brush holders gets damp and causes trouble. Removing it and drying it, by either wiping it dry or baking it in a dry heat for a short time, will overcome the trouble and cause the generator to work successfully again.

445. Above all, we would advise any one installing one of these little generators to provide it with an absolutely clean place, and one which can easily be kept clean. It should be so located that no oil from the engine or other machinery can be spattered on it. It should be excluded from dust and dampness by incasing it in a roomy box if the room

in which it is placed is at all exposed to dust, dirt or dampness.

446. If the friction wheel is used on the generator for driving purposes, it (the generator) should be set so that the little friction wheel sets squarely against the face of the flywheel of the engine, and so that it is in direct line with the flywheel. Otherwise the face of the little friction pulley would soon wear out of true and cause trouble. It should also set up snug enough against the face of the flywheel to insure a generative speed of the generator when the engine is running at its normal speed.

447. The easiest way to operate a generator successfully is to keep its parts and surroundings perfectly clean and dry.

If you will do this, you will seldom have occasion to correct what might otherwise appear to be a fault of the generator. Dampness and dirt are the direct enemies of the successful running of the generator. Lubricating oil becomes dirt when used too freely.

448. If copper wire brushes are used, they should be soaked in oil occasionally to prevent cutting the commutator.

Carbon brushes will not cut the commutator, but may become glazed, which will prevent a reliable contact. The ends should be filed off to a new surface.

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